THE

SALINE DEPOSITS OF CALIFORNIA

GILBERT E. BAILEY

Relief Map

— OF —

CALIFORNIA

By N. F. DRAKE,

Department of Geology, Leland Stanford Jr. University.

Accompanying Bulletin No. 24,

The Saline Deposits of California,

ISSUED BY THE

STATE MINING BUREAU,

FERRY BUILDING,

SAN FRANCISCO.

LEWIS E. AUBURY,

State Mineralogist.

CALIFORNIA STATE MINING BUREAU.

FERRY BUILDING, SAN FRANCISCO.

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CALIFORNIA STATE MINING BUREAU,
May 1, 1902.

To HON. HENRY T. GAGE, *Governor of the State of California; The Honorable the Board of Trustees of the State Mining Bureau; and* HON. LEWIS E. AUBURY, *State Mineralogist:*

GENTLEMEN: I have the honor to submit herewith the report of my reconnaissance of the salines of California. Most of my time since October, 1900, has been spent in traveling over the deserts of the southeastern portion of the State, studying their geology. Nature has been bountiful in giving to California salines which await the union of capital and technical skill to become valuable producers of State and National wealth. The main source of this wealth of natural soda, borax, niter, etc., are the alkaline lakes, "dry deposits," and beach lines of the Great Basin.

As there is practically no literature on the subject, beyond articles to be found in journals inaccessible to those most interested, it has been deemed advisable to bring together in as compact a form as possible the existing information as to the localities of the deposits, and to give some suggestion as to their geological history and origin. In order to publish anything like a complete description of the saline resources of the State, the hearty coöperation of each prospector and mine-owner connected with these resources is necessary. The present heavy expense of exploration in the desert made it impossible, often, for me to turn aside or turn back from a given route to look at some recent find, no matter how great my desire.

The economic importance of the desert lakes of the Great Basin lies in the practically unlimited quantities of sodium salts they are capable of yielding, and a list is given as a guide to show the prospector his approximate position on the map.

Water is one of the most important factors in the exploration and development of the resources of the desert. The location of springs and wells is therefore given as accurately as present data will permit.

The technology of the salines has its special difficulties, since laboratory experiments on a small scale, no matter how carefully conducted, can rarely reproduce the condition existing in large masses of the raw material. As these difficulties have to be met by the scientific specialist, and not by the prospector, it was not thought necessary to do more than note a few points in connection with the many processes. At a later date a bulletin on this subject would be of value to those engaged in developing these resources.

Some of these deposits are too weak, too impure, or of too little extent to have prospective value; but the majority promise good results to well-directed, practical development.

If the reports on certain districts seem meager, it should be remembered that a majority of the locations of niter lands, etc., was made in 1901, and that but little development work has been done on them. There is no question, however, but that rapid progress will be made in the development of these resources within the next two years.

It would seem that the time must soon come when these vast resources will attract the serious attention of capital and business enterprise. The path is open. The general chemical lines are already well known, and the engineering problems, while numerous, are neither very complex nor very difficult. Through the present steady development of transportation facilities, the arid region will soon become the seat of new, great, and prosperous industries. That these deposits will be developed is not doubtful to any one who knows the activity and enterprise of our people.

Photographs were taken freely, and copies and the negatives have been filed with the State Mining Bureau. It is hoped that the photographs and maps will do as much to show the resources of the "desert" as the written notes. The object kept in view has been to give, as briefly as possible, the essential facts in a way that will aid the prospector and business man, and not to burden the pages with purely scientific or geological discussions.

To the many persons who kindly gave every assistance to the work, my hearty thanks are extended.

Respectfully yours,

G. E. BAILEY.

THE SALINE DEPOSITS OF CALIFORNIA.

PART I.

THE GREAT BASIN.

With the exception of salt made from ocean water, the great bulk of the salines of California, the borax, niter, soda, and salt, is found within the boundaries of what is known to the geologist as "The Great Basin."

To describe each deposit separately would require a volume several times the size of this bulletin; and there would be much unnecessary repetition of geological and chemical facts. The following birdseye view of the Great Basin and its main features may serve as a guide to the student of the valuable, curious, and most interesting salines of the great desert regions. However fragmentary the geology of a single vein of borax or rock salt, or bed of soda or niter may seem, it should be remembered that the history of the earth is a continuous record, that the processes of nature have been the same everywhere throughout the ages, and that though many miles may separate similar deposits, their history is the same.

1 THE GREAT BASIN.

The Great Basin is characterized by a dry climate, by interior drainage, and by a peculiar mountain system. Its later geological history includes changes of climate, changes of drainage, volcanic eruption, and displacements of the earth's crust. The basin is bounded on the north by the drainage basin of the Columbia, on the east by the Colorado, on the west by the basins of the San Joaquin and Sacramento, and on the south by the Sierra Madre divide. Its extreme length from northwest to southeast is about 880 miles, and the extreme width from east to west is about 572 miles, or a total area of some 210,000 square miles. This vast region between the Rockies and the Sierras stands in all its scenic features in marked contrast with all the rest of the United States, and is only comparable with the deserts of Arabia and Africa.

The Caspian, the Aral, and the Dead Sea in southern Asia, the Sahara in northern Africa, and the Plains of Tarapaca in Chili, are the evaporating basins of similar vast, independent, hydrographic areas, of which the Great Basin is the only typical example on this continent.

At the end of the Palæozoic era, the whole of the Great Basin had subsided and was covered by an immense inland sea, comparable in size with the Mediterranean. At the close of the Jura-Trias period, the great Sierra Nevada range was born, and the inland sea began to evaporate.

During the Tertiary period, vast deposits of clays, marls, and salines were made, and the dry bottom of the great sea became a desert more arid than that of to-day. With the coming of the Glacial epoch, the Sierras were covered with giant glaciers that sent their waters into the basins below. Other ranges around the Basin did the same, and four vast lakes were formed in the Great Basin.

The history of two of these lakes has been published in the volumes of the U. S. Geological Survey. Lake Bonneville filled the depression along the eastern border of the Great Basin, and its lowest depression is now known as the Great Salt Lake of Utah. Lake Lahontan filled a similar depression along the northwestern portion of the Great Basin, and the remains of its position are marked by the lakes now known as Winnemucca, Humboldt, Carson, Walker, etc. A third lake filled the southwestern portion of the Great Basin, and its lowest pools are now known as Death Valley, Owens Lake, and the host of dry lakes and sinks of the Mójave Desert. The fourth lake filled the area now known as the Colorado Desert, and its lowest pool is marked by the Salton Sea.

Neither of the last two lakes has heretofore been described or named. It is suggested and proposed, therefore, that the

ENTRANCE TO DEATH VALLEY, INYO COUNTY.

CROSSING THE BORAX CRUST, DEATH VALLEY, INYO CO name of "*Lake Aubury*" be used to designate the third lake that once spread from Death Valley over the Mojave Desert, in honor of the Honorable Lewis E. Aubury, State Mineralogist of California, who is the first to especially examine the economic geology of these desert regions. "*Lake Le Conte*" is proposed as the name of the fourth lake, whose remnant is now known as Salton Sea, in honor of Professor Joseph Le Conte, whose name will ever be closely associated with all that pertains to geology in California.

The bedrocks of the desert, and the lower deposits that formed the beds of Lake Aubury and Lake Le Conte, date back to the Jura-Trias and Tertiary oceans. They were fresh-water lakes that were contemporaneous with Lakes Bonneville and Lahontan, and the names given are useful to distinguish the Quaternary lakes, as a whole, from the remnants now known as the lakes of the desert, like Death Valley, Sink of the Mojave, Salton Sea, etc.

These fresh-water lakes were born from the snow and ice of the Glacial epoch, and reached their greatest extension in late Quaternary times, and were synchronous in their fluctuations with the advance and retreat of the glaciers. It may be of interest to note here that James Croll, from astronomical data, places the end of the Glacial epoch at 80,000 years ago, but others claim that this time is much too short. At any rate, the remains of spear and arrow heads of obsidian, and the fossil bones of mastodon, horse, and camel, mingled together, tell the story that elementary man lived along the shores of these ancient lakes.

The underlying rocks of Lakes Aubury and Le Conte are the slates and schists of the Jura-Trias period, highly metamorphosed as the result of the intense volcanic action that has scattered lava broadcast over the desert. Next above are the Tertiary clays, bedded on the upturned edges of the older rocks, in horizontal and undisturbed strata; and next above them the deposits of the great Quaternary lakes.

The physical history of these lakes is recorded in terraces, grand embankments, deltas, sedimentary deposits, river channels, mineral deposits, and products of desiccation that would take a corps of scientists months to map and study, and huge volumes to describe fully.

The glacier-fed lakes were at first fresh-water lakes; but rivers take up a certain amount of saline matter from the rocks and soils, and such rivers emptying into lakes having no outlet make the water saline at last, as the saline matter leached from the earth accumulates in the lakes without limit.

Ages of erosion, detritus of great floods and cloudbursts, deposits from the beds of former seas, and sand storms, have each and all contributed their quota in filling up these lakes.

2 BASIN RANGE STRUCTURE.

In the deserts of the Great Basin, the three main features,-mountains, valleys, and springs, have characters wholly their own, and unlike those found elsewhere.

The mountain ranges are like long narrow ridges, with a general north and south direction, steep on one side where the broken edges of the composing beds are shown, but sloping on the others; and were formed by the tilting of blocks that are separated by profound faults. It is as if an ice field had cracked and one edge of the blocks had been pushed up.

This type of monoclinal is so different from the great curves of the anticlinal and synclinal commonly observed in mountains that it is now generally recognized by geologists as the "Basin Range" structure.

3 SCENERY.

If nature has been unkind in some ways in the desert, she has been lavish of her gifts in others. If the valleys look forbidding, yellow with sand and greasewood, and spotted with dismal black lava buttes, yet they are brightened with beds of soda, salt, and borax that gleam snow-white to the eye, or turn to mirage lakes with dancing waters and leafy borders. Every peak, face, ledge, gorge, and stratum has a color of its own, while no two breadths of color are exactly alike. They vary from pure marble white to lava black, from palest green to darkest carmine, from delicate cream to royal purple. Brilliancy and dullness of color are all mingled, contrasted, and blended in magnificent masses that are beyond description. Even the desert plants are gray or yellow as the soils they grow in. It is the land of the paradox; a veritable desert, yet filled with abundance of riches; a region of death, yet for one half of the year one of the healthiest places on the continent; a place where the temperature may jump from 120° in the shade to 40° below zero during the year; where the average rainfall annually is *nil*, yet cloudbursts rip out the sides of mountains and change the face of nature in an hour; a place where beds of lakes are found on the pointed peaks of the mountains; where the rivers preserve their life only by concealment under the gravels, coming to the surface only when forced to by some rocky barrier, so that the bottoms of the rivers are on top; and where one "cuts his wood" by digging into the sand with pick and shovel. It is an arid land, where men have died of thirst even with full canteens in their hands; it is a "waterless desert," yet its springs are the favorite stopping-places of myriads of migrating ducks and geese. The ranges and the plains between them are absolute deserts, treeless and destitute of water, except at springs miles apart; yet at many of the springs, where there is enough water to irrigate the land, ranches have been established that are veritable oases, delighting the eye of the weary traveler, and furnishing him with new supplies of fruit, vegetables, and hay.

The scenery contrasts sharply with that of the rain-blest regions. In the Great Basin, the russet-brown and gray desolation of the valleys, the naked rocks gorgeously colored, and the sharp, forbidding, angular outlines of the mountains, all form a picture of desolation and solitude that is oppressive to the traveler. The scenery is monotonous in the extreme, yet it has a grandeur of its own.

There is a lack of shadow and an absence of relief that make the distance deceptive. The glare of the noonday sun conceals, rather than reveals, the grandeur of this rugged land, which is best brought out in the rich colors of sunrise and sunset. As the sun sinks, and the shades grow deeper and deeper, each ravine and cañon becomes a fathomless abyss of purple haze, shrouding the bases of gorgeous towers and battlements, that seem encrusted with a mosaic more brilliant and intricate than that of Venetian artists; and, as the twilight deepens, the ranges become sharp silhouettes drawn in deepest purple against a brilliant sky.

4 BELOW SEA-LEVEL.

The grewsome name of Death Valley was given to the lakebed in Inyo County on account of the disaster to the Bennett party of emigrants in early days, and because the bottom of the old lake is below sea-level. There is nothing strange in

CROSSING A PLAYA LAKE—MESQUITE LAKE, INYO COUNTY.

A DESERT WOODPILE—MESQUITE COVERED WITH SAND; AND SAND ERODED BY WIND ALONG THE EDGE OF A PLAYA LAKE—MESQUITE LAKE, INYO COUNTY. FUEL IS OBTAINED BY DIGGING INTO THESE SAND PILES.

the fact that the bottom of a great lake should be below sea-level; the bottom of Lake Michigan is 246 feet below ocean-level; that of Lake Superior is 351 feet; that of the Caspian Sea is 3600 feet; and that of the Dead Sea is 2500 feet below ocean-level. The very lowest point of Death Valley is about 15 miles east of Telescope Peak, which has an elevation of 10,937 feet above sea-level, or 11,364 feet above the lowest valley, which is 427 feet below sea-level. Mount Whitney, 14,898 feet, the highest point in the United States, is about 50 miles west of the lowest point in Death Valley, or the lowest point on the continent.

The town of Salton, on the Southern Pacific Railroad, in the Colorado Desert, is 265 feet below sea-level, having for its high mountain, to the west, Mount San Bernardino.

5 CLIMATE.

The climate of the Great Basin has proven "good stuff" for newspaper yarns and magazine stories, and its trails are not proper roads to be traveled by the incompetent and ill-equipped "tenderfoot." Its trails have been marked by the wrecks of abandoned wagons, by bleaching skeletons, and by rudely mounded graves; but the trails are giving way to roads, and the "graves" to piles of tin cans around the springs and along the roads, so that every desert now has its "tin lining." A decade ago it was thought that no white man could work and live in the desert, and that it was a place where only the noble red man could earn his living by the sweat of his squaw. To-day, there are ranches in Death Valley and a town at Salton. Mojave and Barstow are "railroad centers," and smelters are operated at The Needles. July and August have their drawbacks, it is true, but the desert has been conquered and rendered habitable, even "below sea-level," in spite of the "climate."

6 SECONDARY LAKES.

As Lake Aubury evaporated, there were formed many smaller lakes, as shown in the accompanying maps. The deepest portion of Lake Aubury was in what is now known as Inyo County. What is now Owens Lake formerly occupied the long valley between the Sierra Nevada range and the Cerro Gordo and Coos mountains. Saline Valley formed another lake. The dry lake in which Ballarat is located filled the depression between the Darwin and Telescope ranges. Butte Lake filled the basin between the two branches of the Panamint range.

Death Valley was bounded by the Panamint, Telescope, and Owl ranges on the west; by the Grapevine and Funeral and Kingston ranges on the east; and by the Avawatz and Shadow mountains on the south. Resting Springs and Tecopah Lake lay east of Death Valley. The drainage of the ancient Ivanpah River made the lake that bears that name. Searles Lake formerly extended over Coos and Salt Wells valleys, as well as the present borax lake.

South of these lakes, what is now known generally as the Mojave Desert was covered by an immense lake, that, later on, shrunk by evaporation to an intricate series of chained lakes, but maps and field work would have to be prolonged for several months to work out their intricate boundaries. The attempt made here is only to call attention, in a general way, to the history of these lakes, leaving the details for future workers in this interesting field.

PLAYA LAKES.

The places where soda, salt, and borax are found have been called many names, such as "dry lakes," "alkali marshes," etc., and the term "marsh" has been especially misleading, because they differ so greatly from the Eastern marshes.

They are desiccated lake-beds, in which the more soluble salts, derived from the rocks of their watersheds, have concentrated for ages, and now form fields of common salt that are in some cases many square miles in area, and hold brine in all stages of saturation in the deep ooze beneath their surfaces.

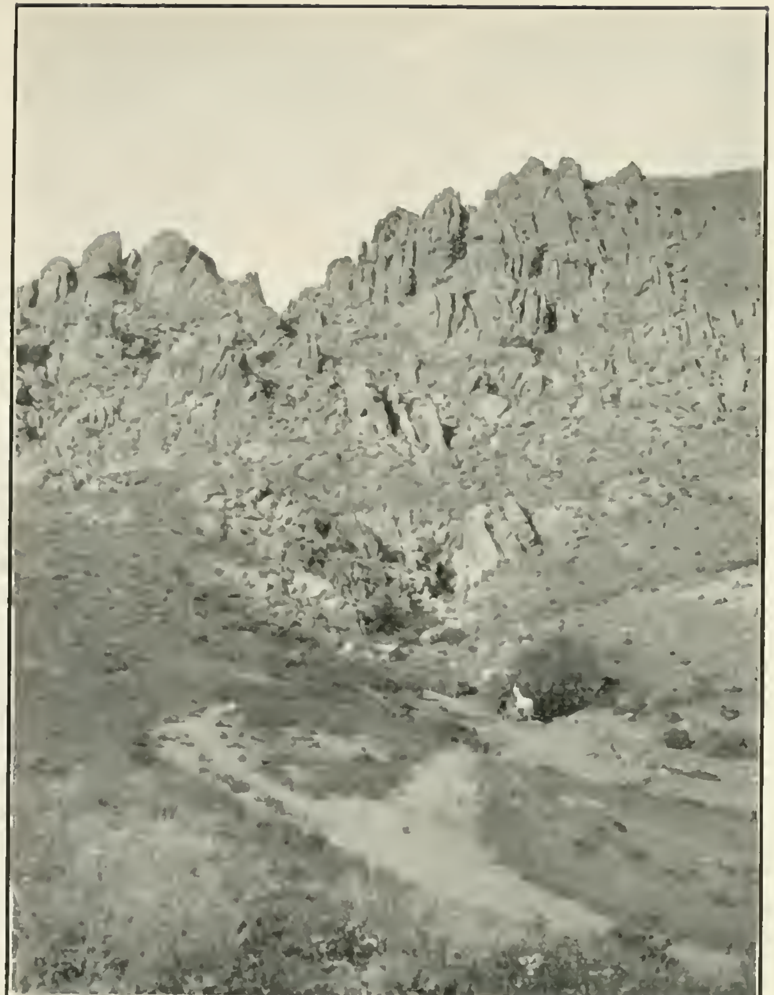
They are not necessarily watery, or soft. They are generally dry lagoons, with a surface incrustation of the salines in some form, such as soda, salt, or borax, and the surface is quite variable in color. The appearance is often that of a bowl of a valley, surrounded by barren mountains. At the bottom of the flat bowl is a vast deposit that looks like water, salt, dirty snow, or chalk, according to local circumstances. Some of these bowls have a hard, yellow-brown floor of clay, forming excellent roads for heavy teams; but generally, on trying to walk across the bottom, one finds it covered with a sandy-looking crust, through which the feet may break, or through which the traveler may suddenly drop out of sight, for below this crust there may be solid clay, or there may be water and slime too deep to probe. After local storms, they may be real lakes for a short time.

They have been formed, (1st), by the isolation of a portion of the ancient lakes in the elevation of their bottoms into land, or, (2d), by the indefinite concentration of river or creek water in a bowl or lake that has no outlet. In general, they are pools that are the remains of Lake Aubury or Lake Le Conte; Death Valley and Salton Sea being simply the largest and deepest of such pools. They are inclosed water-basins, which have little depth of water on the surface, and often evaporate to dryness, leaving mud plains or "*playas*." They may be miles in extent after a storm, but disappear as soon as the hot breath of summer touches them, becoming once more "soda lakes," "river sinks," etc.

These ephemeral lakes exert a curious effect upon the scenery of these arid lands, with their smooth, cream-colored mud plains stretching often to the horizon, without even a shrub or spear of grass to break the monotony of the glossy surface. They are the playground of mirage and optical illusions; the heated air is filled with fairy cities, fanciful forms of mountains, and grotesque caravans that divert the attention of the experienced traveler from the fatigues of the journey and from the profound and oppressive stillness of these solitudes. They are perilous, however, to the thirsty or lost wanderer, for to him they are the Lakes of Tantalus, whose ever-receding waters are magical visions that cause Reason to topple from her throne and lure him to a cruel death.

8 FISSURE SPRINGS.

There are few "hillside" springs in the desert, whose source is in the rainfall of the immediate neighborhood. Nearly all of the springs are "fissure springs," occurring along the faults where the earth's crust is broken, their water supply being derived from regions remote from the point of discharge. Owing to the depth to which these waters descend during their long subterranean passage, and the heat and pressure to which they are subjected, they become active solvents of mineral matter, and issue along the edges of the monoclinals as warm



LEACH'S PEAK, SAN BERNARDINO COUNTY.

SARATOGA LAKES, DEATH VALLEY, SAN BERNARDINO CO.

or hot springs, carrying many salts in solution. Nearly all who have traversed the desert will remember these springs at Saratoga, Owl Holes, Bennett's Wells, Resting Springs, etc., and also what a delight it was to get the pure waters of Leach, Kingston, or Paradise springs.

9 ORIGIN OF THE BORATES.

When fissure springs rise in the bottom of a saline lake, a new element is introduced into its history. The fissure springs rising into Lakes Aubury and Le Conte, charged from volcanic vents with boric acid and carbon dioxide, gave rise to borax deposits and to other curious and interesting results.

The original source of borax is probably in all cases volcanic emanations, the hot springs of Tuscany illustrating the active stage in its production, while the Great Basin shows the work of ages past.

Among the interesting compounds formed by boric acid in the bed of Lake Aubury are the following: Combined with soda, it formed the borax of commerce; with soda and lime, it formed ulexite; and with lime, the mineral colemanite; with magnesia, it formed boracite; while in the pure state, it is known as sassolite.

Rivers have affected these deposits but little, for the few meager streams that are called rivers, by courtesy, the arteries of this parched and heated country, make but one feeble pulsation a year, and are clearly degenerates, for they are larger at the head than at the mouth.

10 AEOLIAN SANDS.

The traveler is apt to make his first acquaintance with these when they are in motion, filling the air with dust, sand, and gravel, which are blinding, choking, and irritating beyond all description, on account of the alkaline material with which they are saturated. Sand spouts, or "sand augers," as the desert men call them, may often be seen as slender, writhing, twisting columns of sand, a mile high, that sag and sway and twist here and there with sinuous grace, only to disappear, ghost-like, as mysteriously as they appeared. When at a distance, he can admire the slender, hollow dust-columns, that sway here and there like pillars of smoke, according to the caprice of Æolus.

Dust storms that last three days are not uncommon, and in the distance look like the clouds of smoke that hang over Pittsburg, or a fog drifting in on San Francisco.

On calm days he can enjoy the huge sand dunes of cream-yellow color, with their beautiful curved ridges and waves, that are covered with a fretwork of wind ripples and the curious hieroglyphic footprints that are the records of wandering animals. These dunes are ever slowly crawling over the valleys and climbing up the flanks of the mountains like huge waves, their contrasts in color bringing out in strong relief the tones and sculpturing of the cliffs. Every zephyr that blows is busy remodeling their rounded domes and graceful curving crests, and in varying the lace-like traceries that give grace and elegance to the structure. Altogether, they form an interesting study.

The presence of sand in large quantities, in the salt, soda, borax, and niter beds, is soon understood, if one studies the æolian sands awhile. At the Searles Borax Lake, it was found that, after a crust had been removed from one part of the marsh, it filled with water that soon deposited crystals of borax, and in six months the waters were blown so full of fine sand that the new crust contained 50 per cent of sand.

These sands account for the presence of sand in all of the playa lake deposits of the deserts.

11 TERRACE DEPOSITS.

The old margins of the great Lakes Aubury and Le Conte are now found far beyond the present shore-lines and several hundred feet above them, showing clearly two great flood periods, separated by a period of complete desiccation. These terraces are composed of alternating strata or layers of sands and clays, that carry also layers and beds of gypsum, rock salt, borax, soda, or even niter, according to locality; forming deposits of commercial value high above the beds of the playa lakes. The borax at Furnace Creek, the niter at Owl Springs, and the beds of salines in the hills, miles away from the present Salton Sea, are examples of these terrace beds. The alternating layers of the terrace deposits are the stony pages that contain the record of the gradual drying up of the two vast lakes of Aubury and Le Conte; lakes that were themselves but the remnants of the vast inland sea that once covered the Great Basin. The terraces and beds exist to-day only where their local position has protected them from the enormous erosion of recent geological times.

The various terraces were originally contour lines, drawn at definite horizons around the borders of the basins by the waves of the lakes. They were, therefore, originally, horizontal and parallel one with another. They are not now horizontal, on account of the movements of the rocks since the evaporation of the lakes.

12 GEOLOGICAL HISTORY.

The results of volcanic action are plainly seen all over the deserts of the Great Basin, in the form of hills of lava, basaltic trap, lava sheets, and in the dikes of diabase and diorite which intrude into the schists.

The changes of each period obliterate a part of the records of its predecessor, and the earlier periods, so that the completeness of our knowledge is in the inverse order of their antiquity.

At the end of the Palæozoic, the portion of the Great Basin covered by Lakes Aubury and Le Conte subsided and was covered by shallow inland seas, not connected with the Pacific Ocean, in which salt, gypsum, and other salines were deposited by evaporation. At the close of the Jura-Trias, the Sierra Nevada was born. The Eocene Tertiary is represented by clay beds, deposited during that long period of subsidence. They appear as some 800 feet of clays, bedded on the edge of the eruptive rocks in horizontal and undisturbed strata, having a peculiar, creamy color.

In the Amargosa River cañon, and elsewhere, the Champlain epoch of the Quaternary period is represented by gravels 150 feet deep, covering the Eocene clays, and it is only where these gravels are eroded that the clay beds appear.

As the geologist reads the records of the past, as written on the pages of stone, he sees that during the Quaternary the Sierra Nevada and other ranges around the desert were crowned with vast snow fields, from beneath which flowed many magnificent ice rivers, or glaciers, that turned what are now desert valleys into vast lakes. He sees that there were three distinct periods of flooding, or filling, these lakes.

The first great rise was preceded by a long period of desicca-

SAND DUNES, DEATH VALLEY.

NITER HILLS, SARATOGA DISTRICT, SHOWING THE ANCIENT BEACH RESTING ON THE FLANK OF THE AVAWATZ RANGE.

tion, and was followed by a second dry epoch, during which the valleys of the district were more of a desert than they are now. During the second flood stage, the lakes rose higher than at the time of the first high water, and then evaporated to complete desiccation. During these three major oscillations, there were many minor ones.

At the times when the two great lakes approached complete desiccation, their pools formed independent areas, or lakes, which completely evaporated. The saline matter precipitated at such times was so completely buried beneath playa deposits that when the lakes were filled with water again, during another oscillation, *the salts were not dissolved again*, being protected by the clay layers and marls that absorbed the efflorescent salines when the lake was greatly concentrated by evaporation. Thus, *alternating evaporation and filling* have been large factors in forming the stratified layers of clays and saline matters now found in the deserts. The débris of floods also assisted in burying the salines, and the ever moving æolian sands have been busy for ages in covering up the products of evaporation, while other salines have been concentrated and buried along the beach and terrace lines.

The borax beds at Calico, and the numerous veins of rock salt and other salines, were buried in a similar way during the Tertiary age, while most of the later layers and beds of salines were formed during the history of Lakes Aubury and Le Conte.

13 VOLCANIC DISTURBANCES.

Lavas in the form of vesicular basalt, pumice stone, volcanic tufa, etc., are found on the ranges of a greater portion of the desert, and their history will form an interesting study for future workers in this field. Much disturbance has taken place since the early Neocene times, and the oscillations to which the desert has been subjected have tilted and plicated the underlying strata.

14 EROSION.

In whatever direction one turns, he is at once impressed with the vastness of the erosion that has taken place everywhere in the Great Basin. The desert is not, as some suppose, a vast plain, but consists of long parallel mountain ranges, inclosing valleys of sand.

Many of these valleys, at the present time, have no outlet. The mountains, with a few exceptions, are destitute of trees and all vegetation except brush, while the valleys are either barren wastes of sand or covered with a scanty growth of "greasewood." The present ranges were formerly from 1000 to 3000 feet higher than they are now, and stood as picturesque islands in the ancient sea. The material eroded from the ranges has covered the desert with gravel washes, sand, sand dunes, scarps, etc., half filling the original valleys. Nearly all the washes contain metamorphic, igneous, and volcanic rocks in fragments.

Sooner or later the "cloudburst" visits every tract of land in the desert, bringing down more eroded material, and redistributes the surface of the washes, obliterating all roads and trails, or making them so rough that only the strongest vehicles can travel over them.

15

CHEMICAL.

According to Bunsen, the composition of the solid crust of the earth, in 100 parts, by weight, is as follows:

	Per Cent.
Oxygen	44.0 to 48.7
Silica	22.8 to 36.2
Alumina	9.9 to 6.1
Iron	9.9 to 2.4
Calcium	6.6 to 0.9
Magnesium	2.7 to 0.1
Sodium	2.4 to 2.5
Potassium	1.7 to 3.1

During the erosion of the mountains, the soda and potash minerals are carried down into the valleys, forming one source of supply.

Another source is from the underground waters, which, under the heat and pressure to which they are subjected, take up salines from the rocks with which they come in contact.

Under the head of Mineralogy, in the section on Borates, it will be noted that a number of minerals carry boric acid in large quantities, and hot fissure springs may derive their boric contents from such minerals.

For example, axinite is a compound of boric acid, lime, and alumina, and is found in granite rocks; the tourmalines all carry from 3 to 12 per cent of boric acid; datolite, a silicate of lime rich in boric acid, is found in trap rocks; danburite, a silicate of lime with 22 per cent of boric acid, is found in dolomite; while others, such as warwickite and szaibelyite, might be quoted to show that the rock formations buried deep in the earth carry boric acid and salines accessible to the action of solvent waters that finally escape to the surface as springs. Similar examples of the other salines may be noted in a study of their mineralogy.

Surface waters derive their chemical impurities mainly from the rocks over which they flow. When draining a granitic or volcanic area, they are rich in potash or soda; when flowing over limestones, they are saturated with calcium carbonate. Such springs and such streams, in the geological ages of the past, entered the two great lakes, and gave to their waters the soda, potash, borax, lime, and niter that they held.

The formation of nitrates, whether in the soil or in the original porous feldspathic rocks, is due to the gradual oxidation by the air of nitrogenous organic matter in contact with an alkali. In order to understand how these deposits were formed, one must know something about what ocean waters generally contain, how soluble the various salines are, and in what order they would be deposited on evaporation.

The voyage of H. M. S. "Challenger" showed that deep ocean water is remarkably constant in its composition; but in the publication of their analyses they disregard the rarer substances, such as the borates and nitrates, confining themselves mainly to the chlorides and sulphates. The general composition of the salines of deep ocean water is given as follows (Chall. Expd., vol. 1, p. 204):

Chloride of sodium	77.7
Chloride of magnesium	10.8
Sulphate of magnesium	4.7
Sulphate of calcium	3.6
Sulphate of potassium	2.6
Bromide of magnesium	0.3
Carbonate of calcium	0.3
	100.0

The average of the total solids in ocean water is 35.19 parts in a thousand.

The rate of solubility of salines is another important point

CAÑON OF THE AMARGOSA RIVER, SAN BERNARDINO COUNTY.

STATE LINE PASS, SAN BERNARDINO COUNTY—PASS BETWEEN NEVADA AND CALIFORNIA, ON THE ROAD FROM MANVEL TO MANSE.

to study in determining the formation of the beds, as waters of complex composition, when subject to slow evaporation, do not deposit their salts, or salines, in a homogeneous mass, but in successive layers or strata of varying composition, the order varying according to the special local conditions. Disregarding the chemical reactions of the salts upon each other, the contained salines will be deposited *inversely as the order of their solubilities;* those least soluble being deposited first and those most soluble being deposited last. The solubility of common salt (chloride of sodium), in water of different temperatures, is as follows:

Temp. of Brine........	32°	50°	86°	104°	140°	176°	229°	
100 parts Water......	35.6	35.6	36.0	36.3	37.0	38.0	40.3	of Salt.

The solubility of sulphate of lime (gypsum) in water is as follows, giving the parts of water required to dissolve one part of gypsum at the given temperature:

Temperature of Brine....	32°	64.5°	100°	127°	212°
1 part of Gypsum	415	386	368	375	458

That is, it would require 458 parts of water, at a temperature of 212°, to dissolve one part of gypsum. Sulphate of lime is, however, much more soluble in salt brine than it is in pure water.

The solubility of niter (nitrate of soda) is as follows, 100 parts of water dissolving the given parts of niter at the given temperature:

Tem.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
Niter.	13	21.1	31.2	44.5	64	86	111	139	173	206	247 pts. of Niter dissolve.

At 114°, the boiling point of the saturated solution, 100 parts of water dissolve 327.4 parts of niter.

It will be seen at once what an important part the temperature of the leaching and solvent waters has played in the formation of the deposits in the deserts.

16 ORDER OF THE DEPOSITS.

The succession of chemical precipitates formed by the evaporation of ocean water has been well described by M. Dieulafait in the Popular Science Monthly of October, 1882.

He gives the deposits one would find (theoretically) by digging down, as follows, counting from the top:

"Deliquescent salts," such as chloride of magnesium, nitrates of soda and potash; "carnalite," or the double chloride of potassium and magnesium; mixed salts, including chloride of sodium and sulphate of magnesium; sea salt, mixed with sulphate of magnesia; pure sea salt (rock salt); pure gypsum; weak deposits of carbonate of lime with sesquioxide of iron, etc.

In the evaporation of lakes like Aubury and Le Conte, this order of deposits would be altered by fluctuations of temperature, variations in density, and other disturbing conditions.

In general, the concentration of surface waters by evaporation produces brines of two characters; in one class, sodium chloride predominates over all other salts; in the other class, the alkaline carbonates are abundant, especially in the vicinity of volcanic rocks.

Should the desiccation be incomplete, the remaining waters would form a dense mother liquor, rich in magnesia, soda, and potash, and containing the rarer substances, such as lithium, nitrates, boric acid, etc.

When the waters of these two great lakes, or inland seas, were evaporated, the process was often interrupted; the desiccation was incomplete, and the niter and borax beds are the results of the final complete evaporation of the dense mother liquors along the shores of the lowest depressions of the bottoms of these ancient lakes.

The causes of some of these interruptions were that the rivers, during their flood season, brought down sediments, and during these flood seasons the supply of water was greater than the evaporation, so that the waters were diluted, and the depositing of salt and gypsum ceased; on the contrary, during the dry seasons the deposits of sediment and mud would be *nil*, while that of the salines would proceed rapidly. Thus the deposits at the bottoms of these lakes would consist of alternations of salt, or salines, and sediments.

Chemical reaction took place also among the various salts as the lakes became concentrated, which affected the nature of the precipitates; and there is much work yet for the chemist to study out fully the genesis of the various borates, chlorides, sulphates, and nitrates formed.

Alternate heating and cooling also promote the depositing of the salts, as shown by the tables of solubilities, and this fact has been taken advantage of in the Balard and Merels processes in manufacturing. The phenomena may also be observed in Salt Lake, Utah, or at Owens Lake, where each year, on the approach of cold weather, the waters lose their transparency and become opalescent with the crystals formed, that soon become portions of the stratified layers along the shore. The heat of summer and the cold of winter had a large share in the depositing of the niter beds along the shores and terraces of Lake Aubury. Where fissure springs charged with boric acid poured their contents into the saline waters of the lakes, or where they came in contact with the sodas already deposited, local beds of borates were formed, and the chemical reactions become more complex.

17 TUFA.

The calcium carbonates are most abundant where the waters of the two lakes were the deepest, and are inconspicuous or wanting where the waters were shallow. They form now the tufas around the shores of the ancient lakes. In some places they have cemented the gravels of the earlier formed terraces and embankments into a compact conglomerate.

18 JOINTING.

The marly clays of the saline beds usually break into prismatic and cubical blocks on weathering; the vertical faces of the blocks being determined by joint planes, and the horizontal by planes of lamination. Some of the bluffs in the cañon of the Amargosa River are cut from top to bottom by joints that have become filled with gypsum. A section of the niter hills in the Upper and Lower Cañon beds shows sediments consisting of fine, homogeneous, evenly stratified, marly clays, which show a distinct lamination parallel with the planes of bedding, laminations that are the result of the slow accumulations of fine sediments and not of pressure, as is the case with many older rocks.

The gravels deposited in shallow waters were much agitated by waves and currents, and present all along the shores of Lake Aubury typical examples of "current bedding," "drift bedding," "cross bedding," "false bedding," etc.

A NITER HILL CAÑON, UPPER CAÑON DISTRICT
INYO COUNTY.

GRAVEL BLUFFS, AMARGOSA RIVER INYO COUNTY.

19 FOSSILS.

The remains of mastodon, camel, ox, horse, etc., in the playa lake at Resting Springs and elsewhere, and the spear and arrow heads of obsidian found in the sediments, show that primitive man lived along the shores of Lake Aubury during the later part of its history.

The remains of a palæotherium were found in the clay banks of the niter bed in the Upper Cañon beds of the Amargosa Cañon, showing that some of these date back to the Eocene Tertiary.

MAP OF

LAKES LE CONTE AND AUBURY.

MAP OF

LAKES LE CONTE AND AUBURY,

To accompany Bulletin No. 24,

"The Saline Deposits of California."

ISSUED BY THE

CALIFORNIA STATE MINING BUREAU.


Mojave Desert
*** DRY LAKES,
To accompany Bulletin No. 24,
"THE SALINE DEPOSITS OF CALIFORNIA."
ISSUED BY THE
CALIFORNIA STATE MINING BUREAU.
Western Portion of Lake Aubury
INYO
KERN
SAN BERNARDINO.
LOS ANGELES
RIVERSIDE
SAN DIEGO
NEVADA
ARIZONA
MEXICO
Pacific Ocean.
Sierra Nevada Mts
Sierra Madre Mts
San Bernardino Mts
San Jacinto Mts
Colorado River
Death Valley
Panamint
Searles
Tecopah
Kane
Willard
Harper
Lanford
Coyote
Soda
Rosamond
Rogers
Danby
Saltan
Northern portion of Lake Le Conte

PART II.

BORATES

20 HISTORY.

California in 1849 started the gold mining industry in the United States, and fifteen years later followed it with the establishment of the borax industry. The twelve tons made at Borax Lake, on the margin of Clear Lake, in Lake County, were the first produced on the American continent.

The young industry thrived for the next four years, although the maximum output of 220 tons in one year would seem small now.

21 FLUCTUATION OF PRODUCTION.

The next three years, 1869, 1870, and 1871, were dark years for those watching the growth of the youngster, for the supply of the pure crystals in the blue mud of the famous little lake had given out, and an unruly artesian well had ruined the waters of the lake by diluting them beyond the profit point.

The deposits of Lake Hachinhama, on the opposite side of Clear Lake, exhausted themselves in yielding 140 tons in 1872.

The prospectors, however, had been aroused to interest in the mineral that was worth over $600 per ton and "only had to be shoveled up to be ready for the market," and discoveries in the deserts of California and Nevada followed each other with bewildering rapidity.

In 1873, San Bernardino County began her big record with the production of 515 tons from the so-called borax "marshes," or the "dry lakes" of the desert. Inyo County soon followed in lively rivalry, and the high-water mark of the early years was reached in 1876, when 1437 tons were produced, worth at that time over $312,000. From 1880 to 1888 the production increased slowly but steadily from 609 to 1405 tons in a year. The year 1887 saw the suspension of work on the "marsh" beds, and the establishment of works on "colemanite" or borate of lime ores, in the Calico district, San Bernardino County. Since the discovery of these beds, large establishments have been erected in Alameda, near San Francisco, at Marion and Daggett, and at Bayonne, New Jersey, for the treatment of borates, and the production has risen from 1405 tons in 1888 to 25,837 tons in 1900. The discoveries in Kern and Ventura counties also led to the establishment of boric acid manufacturing by the Stauffer Chemical Works of San Francisco, and the making of borax by the Chas. Pfizer & Co. works of New York.

22 FLUCTUATION IN VALUES.

When borax was first made in California, in 1864, the value of the refined article was 39 cents per pound, or $780 per ton. In spite of the discovery in Lake County, the price, while gradually declining, did not fall below 30 cents until 1873, when the borax "marshes" of San Bernardino County produced over one million pounds, worth 24⅘ cents per pound, or $496 per ton.

The next year, 1874, saw the price fall to 14⅕ cents per pound, or $284 per ton, and the decline continued until 1879, when it stood at 9 cents per pound, or $180 per ton. From 1880 to 1883, the price varied from 12¼ to 14¾ cents per pound, or from $245 to $295 per ton. Prices in New York varied more widely than on the Western coast, as may be noted from one incident of many that might be quoted. In January, 1883, a tariff law was enacted that went into force in July of that year. During this six months, while imports were free from duty, 2500 tons of boric acid, equivalent to 3500 tons of borax, were imported. This, added to the large accumulations of the home manufacturers, caused the price to drop to 4½ cents per pound in New York, or less than the cost of production.

On the Coast, the result was that the producers combined and waited for living prices. From 1888 to 1894, the price stood still, practically, ranging from 6 to 7½ cents per pound, or from $120 to $150 per ton. Since that time, the value of

BARTLETT'S BORAX WORKS, DAGGETT, SAN BERNARDINO COUNTY.

HUMPHRIES'S BORAX WORKS, DAGGETT, SAN BERNARDINO COUNTY.

the refined article has been 5 or 6 cents per pound on the Coast, and about a cent higher in the East.

Owing to the establishment of the immense works in New Jersey, the shipments to the East are mainly in the form of crude borates, worth from $20 to $35 per ton, according to purity. The depression in prices, owing to rivalry between companies competing for the market, has been done away with, and the industry has outlived the disturbing features incident to youth, and has finally settled to a more certain and stable basis.

While the margin of profit is too small to permit the working of any but the most favorably located and economically handled deposits, yet the prevailing low prices are evidently causing an increased consumption of borates in the arts and manufactures in which they have been employed, and new uses are being continually found for the various compounds of boric acid. In this extended and ever growing consumption, the manufacturers find their compensation for low prices.

The following notes and tables give some of the history of the borax industry in detail.

23 HISTORICAL NOTES.

1856. On January 8th, Dr. John A. Veatch first discovered the existence of borax in the United States. He had been boiling some of the water from the Lick Spring (or Tuscan Spring, as it was then called), and happened to set the water aside when it was concentrated enough for the crystals of biborate of soda to crystallize out. Noting the crystals on the side of the vessel when he resumed work, he tested them, and the discovery was made. These springs where the discovery was made are located on Section 32, Township 28 North, Range 2 West, Mount Diablo base and meridian.

In the same year, the Doctor discovered the presence of borax, in small quantities, at the mouth of Pitt River, Shasta County, and traces of the saline in a number of the springs along the Coast Range, but it was not until September that he visited Clear Lake and examined the borax lake or marsh on its eastern side and found the locality that was to prove the first producer of borax in the Americas.

1860. Dr. John A. Veatch discovered traces of borax in Mono Lake, Mono County.

1863. J. W. Searles discovered borax in "Borax Lake" or Searles Lake, near the northwest corner of San Bernardino County, adjoining the Inyo County line, but did not follow up his discovery. This deposit, which had large works upon it later on, is in Townships 43 and 44 East, Range 25 South, M. D. M.

1864. The industry of producing borax began at Borax Lake, Lake County, with the production of 24,304 pounds, worth 39 cents per pound.

1864 to 1868. During this time, the production was wholly from Borax Lake, Lake County.

1865 to 1871. The value of borax fell from 37½ to 31¼ cents per pound.

1869, 1870, 1871. No borax made, owing to the flooding of Borax Lake by an uncontrollable artesian well.

1871. In October, the new mineral "Priceite" was discovered by Lieutenant A. W. Chase, and named after Thomas Price, the well-known mineralogist of San Francisco, who made the first analyses of the mineral.

1872. The production of borax resumed at Lake Hachinhama, near Clear Lake, Lake County.

1873. Borax discovered in Kern County, at Mesquite Springs (also known as Desert Springs, Kane Springs, and Cane Springs). The discovery was made in February in Township 30 South, Range 38 East, M. D. M. This year saw work started vigorously also at Searles Lake in San Bernardino County, and the industry began to assume importance.

1873 to 1881. The principal production was from the "marshes" of San Bernardino County.

1874. In April, J. W. Searles, David Searles, E. W. Skillings, and J. D. Creigh located the Borax Lake, in the northwestern corner of San Bernardino County, that is known as Searles Lake. There was a borax "boom" in Inyo County, 150 quarter-sections of land in Saline Valley being entered as borax land at the United States Land Office at Independence.

1874 to 1878. The value of borax steadily declined, from 14 cents to 8 cents.

1878. Combinations were formed to increase the price, which led to the formation of new rival companies.

1880 to 1887. Value 12¼ cents in 1880, but declined steadily until it reached 5¾ cents in 1887.

1882. Veins or beds of colemanite (borate of lime) were discovered in the Calico district, San Bernardino County. The mineral was named after W. T. Coleman, who was associated with F. M. Smith in its discovery. The principal production was from the "marshes" of San Bernardino and Inyo counties.

1883. Work begun at the mouth of Furnace Creek, in the north end of Death Valley. The discovery of the Calico district deposits caused a fall in the price.

1883 to 1886. The principal production was from the marshes of San Bernardino and Inyo counties, and the colemanite beds of the Calico district.

1887. Suspension of the working of the "marsh" beds.

1888. The Pacific Coast Borax Company formed a combination of the various works that kept up the price until 1895, the value being for those years from 7 to 7½ cents per pound.

1888 to 1893. The principal producers were the works at Calico, in San Bernardino County, and Saline Valley in Inyo County.

1894. Seventeen hundred acres of borax lands were located at the Salt Wells in the southern part of Inyo County.

1895. Borax was located in Saline Valley, 18 miles north of Keeler. Price of borax fell to 5½ cents per pound.

1897. Work begun on large factories at Bayonne, New Jersey.

1897 to 1901. Value of the crude borax was from $20 to $25 per ton.

1898. The production of borax fell off. The "Borax Consolidated Ltd.," an international borax combine, was formed, owning property in the United States, England, France, and South America. Capital, $7,000,000, $4,000,000 being preferred stock and the rest common stock.

Work was begun on the erection of a 100-ton plant at Borax Lake, San Bernardino County, near the old Searles works, but was not completed, the property passing into the hands of the syndicate the next year.

The railroad from Daggett to Calico completed to the borax mines.

1899. Borax discovered in Ventura County. The extensive works for borax and boric acid completed at Bayonne, New Jersey. The borax syndicate secured control of all but two of the then existing California works.

1899 to 1901. The profits of the Borax Consolidated Ltd. were $1,363,705, an increase of $30,000 over that of the preceding year.

24 Borax Production in California.

YEAR.	Production.	Value per lb.	Value per ton	Total Value.	REMARKS.
	pounds.	*cts.*	*dolls.*	*dolls.*	
1864....	24,304	39	780	9,478	Lake Co., Borax Lake.
1865....	251,092	37½	750	94,099	Lake Co., Borax Lake.
1866....	401,632	33	660	132,538	Lake Co., Borax Lake.
1867....	439,824	35½	710	156,137	Lake Co., Borax Lake.
1868....	64,513	33⅓	666	22,384	Lake Co., Borax Lake.
1869....	Nil.	35⅕	704	Nil.	None produced.
1870....	Nil.	30⅕	604	Nil.	None produced.
1871....	Nil	31¼	625	Nil.	None produced.
1872....	280,000	32	640	89,600	Lake Co., Lake Hachinhama.
1873....	1,030,000	24⅘	496	255,440	San Bernardino Co., 750,000 lbs. Other counties, 280,000 lbs.
1874....	1,829,771	14⅕	284	259,427	San Bernardino Co., 1,729,891 lbs. Other counties, 99,980 lbs.
1875....	2,336,000	12⅜	247½	289,080	San Bernardino Co., 2,147,000 lbs. Other counties, 189,000 lbs.
1876....	2,873,909	10⅞	201¾	312,537	San Bernardino Co., 2,752,000 lbs. Other counties, 121,909 lbs.
1877....	1,986,970	9¾	195	193,705	San Bernardino Co. "Marshes."
1878....	740,840	8⅞	161¾	66,257	San Bernardino Co. "Marshes."
1879....	727,146	9	180	65,443	San Bernardino Co. "Marshes."
	tons.				
1880 ...	609	12¼	245	149,245	San Bernardino Co. "Marshes."
1881....	690	13¾	275	189,750	San Bernardino Co. "Marshes."
1882....	732	13¾	275	201,300	San Bernardino and Inyo Co. "Marshes."
1883....	900	14¾	295	265,500	San Bernardino and Inyo Co. "Marshes."
1884....	1,019	9¾	195	198,705	San Bernardino and Inyo Co. "Marshes."
1885....	942	8¼	165	155,430	San Bernardino and Inyo Co. "Marshes."
1886....	1,285	6¾	135	173,475	San Bernardino and Inyo Co. "Marshes."
1887....	1,015	5¾	115	116,725	

Borax Production in California—Continued.

Year.	Production.	Value per lb.	Value per ton	Total Value.	Remarks.
	tons	*cts.*	*dolls.*	*dolls.*	
1888	1,405	7	140	196,636	San Bernardino, Calico District, Ventura Co.
1889	965	7	140	145,473	San Bernardino, Calico District, Ventura Co.
1890	3,201	6	120	480,152	Inyo Co., refined, 115 tons. San Bernardino Co., refined, 1,487 tons.
1891	4,267	7½	150	640,000	San Bernardino and Inyo Counties.
1892	5,525	7½	150	838,787	San Bernardino and Inyo Counties.
1893	3,955	7½	150	593,292	San Bernardino and Inyo Counties.
1894	5,770	7	140	807,807	San Bernardino Co., 5,189 tons. Inyo Co., 581 tons.
1895	5,959	5	100	595,900	San Bernardino Co., 5,559 tons. Inyo Co., 400 tons.
1896	6,754	5	100	675,400	San Bernardino Co., 6,505 tons. Inyo Co., 249 tons.
1897	8,000	6¾	135	1,080,000	San Bernardino and Inyo Counties.
1898	8,300	6	......	1,153,000	San Bernardino Co.
1899	20,357	6	120	1,139,882	Inyo Co., refined, 200 tons. Kern Co., refined, 27 tons. San Bernardino Co., refined, 5,880 tons. Ventura Co., crude, 250 tons, at $26. San Bernardino Co., crude, 14,000 tons, at $35.
1900	25,837	5	......	1,013,251	San Bernardino Co.
1901	22,221	7¼	......	894,505	San Bernardino, Ventura, and Inyo Counties.

25 General Production of Borax.

(Metric tons).

Year.	United States.	Chili.	India.	Germany.	Italy.	Peru.	Turkey.
	Calcium Borate.	Calcium Borate.	Borax.	Boracite.	Boric Acid.	Calcium Borate.	Pandermite.
1894	5,950	6,700	367	176	2,746	800	9,100
1895	6,126	4,532	400	150	2,633	4,000	9,081
1896	12,310	7,486	340	184	2,616	1,179	12,626
1897	17,600	3,168	280	198	2,704	11,850	11,375
1898	13,911	7,034	184	230	2,650	7,178	....
1899	21,834	11,951	....	183	2,674	7,638	....

26

Value of Refined Borax.

Year.	Average Price per Pound.	New York Price.		Remarks.
		Highest.	Lowest.	
	Cents.			
1864 ...	39	Oct., 50	Mar., 28	First product in America, Lake County.
1865	37½	Feb., 44	Sept., 31	125 tons produced in California.
1866 .	33	Dec., 35	July, 31	200 tons produced in California.
1867....	35½	Nov., 37	Mar., 34	220 tons produced in California.
1868....	33⅓	Sept., 38	July, 34	32 tons produced in California.
1869....	30⅓	Mar., 40	Jan., 30	None produced in California.
1870....	35⅓	Mar., 35	Jan., 30	None produced in California.
1871....	31¼	July, 37	Jan., 30	None produced in California.
1872....	32	May, 38	Jan., 30	140 tons produced in California.
1873....	24⅓	Feb., 38	Sept., 24	515 tons produced in California. Discoveries in Kern and San Bernardino Cos.
1874 ...	14⅓	Feb., 24	Dec., 14	915 tons produced in California. Boom in Inyo County.
1875....	12⅜	Nov., 17	Jan., 12	1168 tons produced in California.
1876 ..	10⅞	Mar., 16	Nov., 10	1436 tons produced in California.
1877 ...	9¾	Jan., 14	Dec., 9	993 tons produced in California.
1878....	8⅞	Jan., 12	July, 7¼	373 tons produced in California. First combine formed.
1879 ..	9	Jan. 11	July, 9	363 tons produced in California.
1880....	12¼	Mar., 12	Dec., 10	609 tons produced in California.
1881....	13¾	Jan., 15	Dec., 13	690 tons produced in California.
1882....	13¾	May, 17	Jan., 13	732 tons produced in California. Calico District discovered.
1883....	14¾	Jan., 16	July, 4½	900 tons produced in California. New Tariff Law.
1884	9¾	....	....	1019 tons produced in California.
1885	8¼	....	....	942 tons produced in California.
1886.. .	6¾	....	....	1285 tons produced in California.
1887....	5¾	....	....	1015 tons produced in California.
1888....	7	....	....	1405 tons produced in California. Pacific Coast Borax Co. combine formed.
1889....	7	....	....	965 tons produced in California.
1890 ..	6	....	....	3201 tons produced in California.
1891....	7½	....	....	4267 tons produced in California.
1892	7½	....	....	5525 tons produced in California.
1893	7½	....	....	3955 tons produced in California.
1894 ..	7	....	....	5760 tons produced in California.
1895 .	5	....	....	5959 tons produced in California.
1896 ...	5	....	....	6754 tons produced in California.
1897....	6¾	....	....	8000 tons produced in California.
1898....	6	....	....	8300 tons produced in California. Borax Cons. Ltd. formed.
1899....	6	....	....	20357 tons produced in California.
1900....	5	....	....	25837 tons produced in California.
1901....	7¼	....	....	22221 tons produced in California.

27 **Imports of Borates into the United States.**

Year.	Boric Acid.		Borates, Crude.		Borax.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1867	770,756	$73,396	5,672	$711	49,652	$6,601
1868	243,993	22,845	22,293	2,985	79,183	10,127
1869	998,033	109,974	54,822	8,011	89,695	12,799
1870	1,166,145	173,806	2,616	322	97,078	14,511
1871	1,204,049	185,477	5	1	134,927	20,705
1872	1,103,974	191,575	22,500	8,000	35,542	6,288
1873	1,222,006	255,186	Nil	Nil	9,284	2,152
1874	233,955	52,752	Nil	Nil	3,860	1,253
1875	41,742	6,280	588	78	5,153	1,224
1876	137,518	15,771	Nil	Nil	3,145	691
1877	107,468	11,231	55	12	3,500	676
1878	22,839	651	286	61	3,492	514
1879	306,462	21,888	Nil	Nil	3,472	490
1880	243,723	18,473	22,122	742	15,278	2,011
1881	187,058	15,771	Nil	Nil	4,136	865
1882	536,335	71,343	Nil	Nil	10,664	3,062
1883	4,334,432	580,171	Nil	Nil	5,611	1,359
1884	44,512	4,494	142	34	7,332	1,691
1885	48,517	4,035	Nil	Nil	240	41
1886	430,655	26,238	4	1	----------	----------
1887	376,184	19,885	33	4	----------	----------
1888	487,777	26,394	455	38	----------	----------
1889	676,736	36,814	Nil	Nil	----------	----------
1890	867,802	43,967	29,608	800	----------	----------
1891	666,765	41,019	414,151	17,681	----------	----------
1892	701,625	39,418	40	6	----------	----------
1893	771,775	40,568	543,967	13,659	11,230	1,327
1894	298,990	19,282	441,006	11,427	1,812	225
1895	925,158	42,056	4,234,261	105,604	612,730	26,429
1896	555,769	21,899	4,307,100	104,951	11,376	796
1897	----------	----------	5,204,612	79,268	19,087	1,128
1898	----------	----------	4,235,856	92,108	10,232	962
1899	582,002	20,560	42,165	2,979	51,221	3,508
1900	473,251	17,436	58,294	4,306	273,706	9,937
1901	725,005	26,629	99,692	8,983	545,045	20,643

COLEMANITE, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

NITER BEDS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY, LOOKING FROM MESA ABOVE THE OLD BEACH LINE. DEATH VALLEY IN DISTANCE. FUNERAL RANGE BEYOND.

BORATES, BY COUNTIES.

28 IN GENERAL.

Until the discovery of natural borax in California, the supply was largely derived by artificial means from boric acid. Boric acid is found among the ejecta of some volcanoes, and in the jets of vapor which issue from fissures in the regions of volcanic disturbances.

The chief source for many years was the Mareninea of Tuscany, a desolate tract of some 40 square miles, which is dotted with jets of steam and heated gases (*soffioni*), and hot springs impregnated with boric acid. The steam and gases were led into water until it was saturated with the acid, sufficiently to crystallize out. Similar emanations of volcanic vapors and boric acid have been discovered in Nevada.

As noted elsewhere, most of the springs of the desert are fissure springs along the line of geological faults, and many of these springs are still hot, or at least warm, showing still the waning energies of once hot springs in regions of intense volcanic activity. Many of the borax "beds" are found in the playa lakes of the desert.

Wherever there is a deposit of borate of soda, carbonate of soda, or salt in these playas, the crust formed by the deposit continuously increases in quantity. The borax permeates the soil as does ordinary alkali, and in favorable situations a crust forms upon the surface. After this has been removed, a new deposit commences to form by the solution of the mineral in percolating waters, and its rise to the surface by capillary action forms a crust by the subsequent evaporation of the boracic waters. After five or six years a new crust is formed. This action of dissolving and evaporation is repeated for ages until nearly pure crystals of borax are formed.

The borax fields are usually very spotted, varying greatly in richness, in general only a small portion of a bed that measures several square miles in area being profitable to work. The carbonate and sulphate of soda crusts on the playas, when mixed with sand, look very much like the borates to the untrained eye, but the difference is readily detected after experience in the field.

The supply of the crude borates is too great to attempt any estimate. It is sufficient to say that the supply is abundant for a century to come, and the production can be increased indefinitely and without difficulty whenever the demand requires it.

29 INYO COUNTY.

In connection with the excitement in Nevada there was a "boom" in borax lands in Inyo County in 1874, and some 150 quarter-sections of land, or 24,000 acres, were entered in the United States Land Office at Independence. Most of these locations were afterward abandoned as not rich enough to work.

In 1883 work was begun at Furnace Creek, and from that time on the county was a steady producer.

While the statistics of the county have not as a rule been kept separate from the other counties in the various statistics published, the following will give some idea of the amount of annual production, which ranks next to that of San Bernardino County. In 1883, Inyo County produced 20 tons; and in 1899, 200 tons, of refined borax.

30 **Bennett's Wells.**—These wells are located at the bottom of Death Valley, near the lowest depression, which is 427 feet below sea-level.

The Eagle Borax Company at one time owned 270 acres here, and had a factory near the springs. The nature of these beds is that of the other beds in this famous valley, which are described elsewhere in this report, consisting wholly of surface incrustations similar to those of Searles Lake.

The borates worked here consist of ulexite, colemanite, and pandermite; associated with an abundance of thenardite, salt, and trona. No work has been done for a number of years.

31 **Confidence.**—Locations cover 2400 acres. Borates in commercial quantities have been found associated with nitrate of soda, sulphate of soda, carbonate of soda, and other salines in the niter beds belonging to the American Niter Company. These beds are located in the southern portion of Death Valley, near the Narrows, and across the valley from the old mill of the Confidence Gold Mining and Milling Company.

As these beds were not located until March, 1901, but little development work has been done upon them up to this date, but preparations have been made by the owners to make extensive explorations of the beds this year with core drills.

32 **Furnace Creek.**—The work done here from 1883 to 1899 probably advertised the borax industry more than all of the work elsewhere put together. The pictures of immense wagons drawn by a string of mules that stretched out apparently for half a mile over the boundless plain, which were scattered all over America, attracted a great deal of curiosity, and led the "New York Sun" to call its correspondent, John R. Spears, back from Central America for the special purpose of writing a book on the subject. This book, "Death Valley and Other Borate Deserts of the Pacific Coast," published in 1892, gives much matter of interest to the curious about the early history of borax in California.

Furnace Creek has shared for years with Yuma, Arizona, the distinction of being the hottest place on the continent, but its name is misleading. Galena ores are abundant in this district, and the creek received its name from the fact that the early prospectors found along the valley the remains of the adobe furnaces used by the Mormons to make lead for bullets in 1857. The creek must take second place to Yuma for heat, as shown by the statistics of the U. S. Weather Bureau, which established a station at Death Valley, at the mouth of the creek, in 1891, and kept an observer there for a season: see "Climatology of Death Valley," by M. W. Harrington, U. S. Weather Bureau, 1892, Washington, D. C.

At the mouth of the creek, a few miles south of the spot where the Bennett party of 1850 is supposed to have perished, there is a ranch known as the Greenland Ranch, with some thirty acres of cultivated ground where alfalfa is raised for the benefit of the Borax Company's stock. All kinds of fruit and garden truck can be raised here.

The bottom of Death Valley all around Township 27 North, Range 1 East, San Bernardino Meridian, is covered with borax deposits, the principal borates being ulexite, colemanite, and pandermite, associated with an abundance of thenardite, salt, and trona. Southeast of the mouth of Furnace Creek, and high up in the hills, W. T. Coleman and F. M. Smith found beds of borax, rich especially in the "cotton ball" variety. These beds are 1500 feet above the valley proper.

The Greenland Salt and Borax Company has been the

AMARGOSA RIVER, SAN BERNARDINO COUNTY. JURA-TRIAS SALINES ALONG THE RIVER BANK.

BOTTOM OF DEATH VALLEY, BORAX FLAT, NEAR SARATOGA SPRINGS, SAN BERNARDINO COUNTY.

principal producer. In order to get its products to market over deep desert sands, and across mountain ranges where the grade for 40 miles averaged over 100 feet per mile, and where water springs were 30 or 40 miles apart, a special wagon had to be invented. These wagons are fully described in Spears's book, but a few points may be of interest. The hind wheels were 7 feet high, the tires were 8 inches wide and an inch thick. Each wagon weighed empty 7,800 pounds, or 15,600 pounds for the two, as two wagons were fastened together "trail fashion." The load for the two wagons was from 45,000 to 46,000 pounds of borax, in addition to water and feed for men. The teams consisted of eighteen mules and two horses, driven by "jerk line." Wheeled water tanks of 500 gallons were towed behind the wagons. In this way the desert was conquered and borax conveyed from the north end of Death Valley to Mojave, a distance of 165 miles, by way of Bennett's Wells, Windy Gap, and Granite Wells.

This property is now owned by the Borax Company Ltd.

A considerable force of men were busy during last winter, 1901-02, in doing assessment work, making improvements upon the claims, and locating more land.

33 **Monte Blanco.**—This is a wedge-shaped peak about 1000 feet high, that stands on the south side of Furnace Creek, at the north end of the Funeral range. The top and sides are covered with borax in the form of a white sandy powder, several feet thick, associated with carbonate and sulphate of soda. A ledge of colemanite has been discovered in the vicinity.

34 **Owens Lake.**—Boric acid in small quantities has been found in the saline waters of this lake, which is fully described elsewhere in this report.

35 **Resting Springs.**—Resting Springs is a well-known stopping-place for all who travel the desert. Mr. Philander Lee has made it his home for many years, and his ranch, with its shade trees, fruits, garden, and alfalfa fields, shows what can be done upon the desert wherever there is water with which to irrigate. North of these springs the valley of the Amargosa River widens out into a playa lake some 18 miles long by 3 or 4 miles wide. Near the south end of this "dry lake" and about 6 miles west of Resting Springs the Amargosa Mining Com-

pany owns several hundred acres of borax land, having selected the best portion of the dry lake. Its lands are in Township 21 North, Range 6 East, S. B. M. The beds are of the usual "playa" character, and have for a cover a thin, dry crust of carbonate of soda mixed with dust from sandstorms.

The borax here is of good quality and requires little treatment. This property also belongs to the Borax Company Ltd., who had a force of men at work in the fall of 1901 doing assessment work. The vats and works of the old Amargosa Mining Company are primitive in design and have not been used for a number of years.

36 **Saline Valley.**—Situated about 18 miles north of Keeler. The Conn & Trudo Borax Company owns several hundred acres in this valley, and had small works for handling the product of the playa deposits. The crust containing borax on the company's land is from 6 inches to 2 feet thick, and in some spots carries as high as 90 per cent of borax.

37 **Salt Wells Valley.**—This is the northern extension in Inyo County of the playa lake known as Searles, or Borax, Lake in San Bernardino County. Some 1700 acres were located in this valley, for borax, in 1874. The Salt Wells Borax Company of Independence was the principal worker here, but no work beyond assessment work has been done for a number of years. On this lake the crust of sodium sulphate is from 3 to 10 inches thick, excepting on the portion covered by a borax crust. An analysis of the borax crust, from a tract of about 100 acres, gives the following:

Insoluble	1.40
Water	44.80
Sodium chloride	16.98
Boric acid	36.82
	100.00

38 **Tecopah.**—The Tecopah Mining District lies at the head of Willow Creek in about Township 20 North, Range 9 East, S. B. M. (unsurveyed); just north of the San Bernardino County line. There is a small lead smelter situated on Willow Creek, and lead and gold mining is active in the range of mountains that extends northwest to the Gunsite mine, near Resting Springs. The playa deposits begin near the smelter and extend east to the top of the low divide near Tule Springs.

The American Niter Company owns about 2500 acres of land, some portions of which are rich in borax. The district is similar in its chemical and geological characteristics to the borax beds around Resting Springs.

39 **Upper and Lower Canon Beds.**—The niter beds of the American Niter Company located in the cañon of the Amargosa River, where it crosses the south boundary of Inyo County, contain considerable quantities of borates, associated with nitrate of soda, etc. These beds are described under the head of Nitrates.

KERN COUNTY.

40 **Buckhorn Springs.**—Travelers over the Santa Fé will probably remember riding for some 8 miles across a large dry lake-bed about 20 miles east of Mojave. At the south end of this playa lake are the Buckhorn Springs, where there are considerable deposits of borates mixed with salt and other salines. The beds have not been developed. The location is in Township 9 North, Range 9 West, S. B. M.

41 **China Lake.**—This playa lake is located partially in San Bernardino County, the county line passing through the playa. It is located in Ranges 40 and 41 East, Township 25 South, M. D. M. It was once a part of Searles Lake, being really a pool or depression in the southwest portion of that lake in recent geological times. The deposits are similar to those of Searles Lake. No work has been done upon these beds.

42 **Indian Springs.**—These beds lie in the west side of the Salt Wells Valley, close to the foot of the main range. Borax is present, mixed with salt, soda, and other salines; but the beds have never been exploited. They are situated in Township 26 South, Range 38 East, M. D. M.

43 **Kane Springs.**—These springs are also known as the Mesquite, Cane Springs, and Desert Springs, and are located in Township 30 South, Range 38 East, M. D. M.

Borate of lime (ulexite) was discovered in the playa lake, around which these springs are located, in February, 1873. The lake is about 9 miles long by 3 miles wide. The rich borate "spots" cover from one to four acres. The deposits were discovered by H. J. Lent, who produced some borax of excellent quality here in the early days; but the beds have lain idle for many years.

44 **El Paso Wells.**—Borates in small quantities are reported as existing near these wells in Township 28 South, Range 40 East, M. D. M.

LAKE COUNTY.

45 **Borax Lake.**—In 1864, the industry of producing borax in the United States was started here with a yield of 24,304 pounds, worth 39 cents per pound. The lake was discovered in September, 1856, by Dr. John A. Veatch. From 1864 to 1868, the little lake yielded 390 tons of refined borax, worth then $414,636, the price dropping from 39 cents per pound to 35 cents. Borax Lake is also called Alkali Lake and Lake Kaysa in the earlier reports. It is situated in the angle of the two eastern prongs of Clear Lake, near a low volcanic ridge that stretches across the cape, forming a triangular valley. In 1863 the lake measured 4000 feet long, by 1800 feet wide, and was 3 feet deep in the winter time; but in the summer it shrinks to a lake of 50 or 60 acres, with but little water. At the bottom of the lake was a layer of soapy mud, some 4 feet thick, underlaid with blue clay. The soapy and gelatinous mud was filled with prismatic crystals of pure borax, ranging in size from the minute to those that weighed several pounds. The waters of the lake, as analyzed by Dr. Wm. O. Ayers, contained the following:

Sodium carbonate	61.8
Sodium chloride	20.4
Sodium biborate	17.8
	100.0

Another analyst states that the water contained 2401.56 grains per gallon of solid matter, of which 538.08 grains represented crystallized borax. The crystals of borax were obtained from the mud by means of a small coffer-dam made of boiler iron, the mud taken out being washed in rude sluices in true placer style, the crystals of borax being caught on the riffles. An attempt was made to evaporate the waters of the lagoon, after the supply from the mud ran short, but this was spoiled by the overflow of an uncontrollable artesian well. The borax made at this place was remarkably pure, as shown by the following analysis made in Edinburgh, Scotland, in 1865:

Biborate of soda (borax), pure and dry	54.39	99.94, common borax
Water crystallization	45.55	
Sulphate of sodium	00.06	
Chloride of sodium	traces	
Insoluble matter	traces	
	100.00	

This natural borax, 99.94 per cent pure, has not been equaled in any subsequent discoveries in any country. It is said that there remains at this place, and at Lake Hachinhama, on the other side of Clear Lake, a large amount of workable borax that may be utilized some day. The whole region around the lake bears the marks of recent volcanic activity, explaining the presence of the borax.

46 **Lake Hachinhama.**—This lake is on the south side of Clear Lake, about 4 miles west of Borax Lake. It was an oval-shaped lagoon of about 300 acres. According to the analysis of Dr. Wm. O. Ayers its waters contained the following:

Sodium carbonate	75.4
Sodium chloride	8.3
Sodium biborate	16.3
	100.0

No crystals were found in the mud here as at Borax Lake. This lake was worked only in 1872, when it produced 140 tons, worth then $89,600.

The discoveries of the "marsh" deposits of the deserts put an end to the production in Lake County.

47 **Springs.**—The presence of borax, boric acid, or borates, has been detected in the waters of the following springs, but not in commercial quantities:

Carbonated Soda Springs.—Described only as 8 miles from Clear Lake.

Hough Springs.

Howard Springs.

Iodine Springs.—On a branch of Stony Creek, near the entrance to Grizzly Cañon; said to be very rich in iodine and bromide, and carrying small amounts of boric acid.

BORIC ACID—DAGGETT, SAN BERNARDINO COUNTY.

BORIC ACID CRYSTALLIZING VATS—HUMPHRIES'S WORKS, DAGGETT, SAN BERNARDINO COUNTY.

HOT BORATE SPRING.—On the edge of Clear Lake, near the sulphur bank mentioned in the Geology of California, Vol. I. An analysis by Mr. Moore shows the following in grains per gallon:

Sodium chloride	84.62
Sodium bicarbonate	76.96
Ammonium bicarbonate	107.76
Sodium biborate	103.29
Alumina	36.37
Silica	8.23
Organic matter	65.77
	483.00

The water also contains traces of chloride of potassium, iodine, and sulphate of calcium.

SARATOGA SPRINGS.

SIEGLER SPRINGS.—These are in a cañon about 18 miles east of Clear Lake. There are three hot springs and several cold ones, the temperature of the hot springs being about 200° F. and that of the cold ones about 60° F. An efflorescence of boric acid is found around the springs; while the water holds in solution biborate, chloride, and sulphate of soda. Free hydrosulphurous acid is abundant, which accounts for the decomposition of the borates of the water and the depositing of the boric acid on the soil. The Indian name of the place is Conotok, on account of the white appearance of the ground.

WITTER SPRINGS.

There is no doubt but that a careful study of the springs would reveal the presence of boric acid in many besides those mentioned here.

A large portion of the eastern ends of these counties is covered by the Colorado Desert, which was once the bottom of the ancient lake now known as Lake Le Conte. Salton Sea, the lowest pool of this old geological lake, is crossed by the line that is the boundary between the two counties. While no borax is being worked in these counties, its presence is known to prospectors in a number of places in the Colorado Desert.

Borate of lime has been found in the foothills of the San Bernardino range northeast of Salton Sea in Riverside County;

and boric acid exists in a number of springs on the San Felipe and Carizzo creeks in San Diego County. Dr. Veatch, in his search for borax in the early days, found boric acid in some quantity in the Mud Volcanoes and on Carizzo Creek. It has also been discovered at Agua Caliente, on Warner's Ranch. The borders of this old lake offer an excellent and promising field for the prospector for borates, and lime borates should be especially looked for. Borax associated with salt, and the carbonates and sulphates of soda are found in many of the playa lakes of the Colorado Desert. No locations for borax or borates have been made in this district.

SAN BERNARDINO COUNTY.

49 **Amargosa River Bed.**—The Amargosa, or Bitter, River is fed in many places along its course by ancient hot springs, and it takes up a certain amount of saline matter from the desert through which it flows, for this desert is but a portion of the bottom of old Lake Aubury. On emerging from a cañon and spreading out over the flat bottom of a valley it soon evaporates, or sinks, so that the saline matter which is ever leaching from its upper courses is being deposited along its lower stretches. The borax permeates the soil, and where the local conditions are favorable it forms a crust upon the surface. These crusts may be removed by local storms, or removed and sent to market by some company; but in either case a new deposit commences to form from the material in the percolating waters as it rises to the surface by capillary action. In some places this double action of dissolving and evaporation has been repeated until nearly pure crystals of borax have been formed.

The Amargosa River has never been known since 1850 to carry enough water to enable it to reach the lowest depression of Death Valley, and in its heaviest floods it rarely goes more than four or five miles below Saratoga Springs.

The enormous evaporation in a region where the average humidity is less than 2 per cent is difficult to realize, and accounts for the beds, patches, and spots of borax that may be found all along the course of this stream from Ash Meadows, where it leaves Nevada, to Death Valley.

While the rate of evaporation has not been definitely ascertained by a series of tests, it is enormous when compared with other regions. For example, experiments at Rochester, New

York, showed 5½ inches per month at the Mount Hope reservoir, with the thermometer standing at 70° in the shade, the humidity in the air being 67 per cent. In Tulare County, in this State, the average taken in August showed 10 inches for the month. In the irrigation districts of India, ½ inch per day, or 15 inches per month, has been measured at reservoirs. It has been the personal experience of some of my party that the thermometer has stood at 120° to 130° F. all night long at Saratoga Springs in the month of July, and that in the latter part of June the rocks became unbearably hot. What the temperature of the Amargosa Valley is in the daytime in midsummer is not known, as "desert men" keep in the shade then, and only attempt to cross the valley at night, if they are unfortunate enough to be in the country at that season. Some tests at the Amargosa borax works in Inyo County, and at Saline Valley, have shown as high as 8 feet of evaporation in a month. Given, then, this exceptional heat in summer, a porous river bottom, an almost absolutely dry air, and it is evident that the river is ever picking up the salines in one portion of its winter course only to deposit them again lower down.

The borax and niter deposits at Resting Springs, Tecopah, Upper and Lower Cañon Beds, Salt Springs, Saratoga, Owl, Round Mountain, Valley, Confidence, Bennett's Wells, Monte Blanco, and Furnace Creek are all in the watershed of this river which sinks in Death Valley.

50 **Calico District.**—The Calico borax district, lying north and northeast of Daggett, has become famous at home and abroad for its borate deposits. Soon after the biborate of soda, or common borax, had been found there, a new mineral was discovered among the brightly colored strata that have given name to the district. This mineral was snowy white, and composed of radiating crystals of singular beauty. To the surprise of those who analyzed it, the mineral proved to be a compound of boric acid and lime. It was named after W. T. Coleman, who was associated with F. M. Smith in the borax industry at the time of the discovery. To give a full description of this rich district would require a large volume, and it is only possible, within the limits of this bulletin, to give some of the salient points as a guide to its more thorough study later on. The colemanite is found in two veins, about 40 feet

BRUSH RACKS FOR CRYSTALLIZING BORIC ACID ON—BARTLETT WORKS, DAGGETT, SAN BERNARDINO COUNTY.

BOILING TANKS—BARTLETT'S BORIC ACID WORKS, DAGGETT, SAN BERNARDINO COUNTY.

apart, that are interbedded with sandstones and sandy clays, on an anticlinal whose apex has been eroded away. On one side of the range the beds dip to the north and on the other side they dip to the south; but both were one bed in the beginning. The portion mined is from 7 to 10 feet thick, and the mineral is stoped out the same as other ores; most of the working being through inclines.

The beds vary in color from red to green and gray, and have somewhat the appearance of indurated mud. Some of the rock is bluish-black in color, and resembles fine-grained blue limestone. Toward the western ends, the borate of lime is mixed with sand, gypsum, clays, and other sediments. The colemanite occurs in the beds in shoots, and the deposits are quite irregular and pockety. The colemanite carries from 15 to 20 per cent of anhydrous boric acid.

The borax "mine" occurs as a bedded vein between sedimentary strata composed of sandstone and sandy clays, that form a succession of heavily-bedded water deposits, as well as shallow, thin-bedded shales and sands; the total series being about 1000 feet thick.

Underlying the sediments are the tufas; and beneath them the liparite that underlies the entire region. There is no metamorphism of the sedimentary strata noticeable in the region of the borates. It is evident that these beds were deposited at the bottom of the southern portion of an ancient ocean; that, in the Tertiary times, there was a local uplift that broke the bowl-shaped bed in two, leaving the strata tipping each way from the uplift. While these beds are of vast commercial importance to-day, geologically considered, they are but local incidents in the destruction of the bed of Lake Aubury.

The origin of such beds is given in the general description of Lake Aubury. As the outcrops of the borates extend along nearly 10 miles of the district, it is evident that these mines will be worked for decades to come.

The Pacific Coast Borax Co.—This company built a crushing and drying plant at Marion, about 4 miles north of Daggett, and a railroad about 10 miles long connecting Daggett, Marion, and its colemanite mines at Calico. This property belongs now to the Borax Consolidated Ltd., which has absorbed most of the properties of this district, and which ships the crude ores, after crushing and drying, to its large works at Bayonne, New Jersey. (These works are described elsewhere under the head of "Processes.")

As permission to go down into the mines was not granted by the superintendent, no description of the present development can be given.

The Owens shaft was, several years ago, over 200 feet deep, and cut a bed of colemanite at an angle of 70 degrees. This bed was reported as from 40 to 50 feet thick, lying in an uplift whose axis is parallel with those of the Calico range.

The Stephens & Greer mine is on the south side of the range on a bed, or vein, about 40 feet thick, which can be traced for over 1000 feet in length.

51 **The Blumenberg Mine.**—Is about two miles south of the Pacific mine, and is on a bed reported as 50 feet thick. This is an independent company which is pushing the development of its property, and expects to erect a plant this year.

52 **The Western Mineral Co.**—Its works are located a short distance west of Marion, on the flat. Their character is well shown in the accompanying photographs.

The works consist of tanks for boiling the crude borates with sulphur, and vats for evaporating the solutions and crystallizing the boric acid. W. T. Bartlett, the owner and manager, is one of the pioneers in this district in the manufacture of boric acid, and it is due to his ability and indomitable perseverance that the problems connected with the working of low-grade borax muds have been solved. The ore used at these works is a low-grade bluish-black, gray or red clayish mud that looks something like a fine-grained shale or sandstone. It is evidently a portion of heavily-bedded deep-water deposits, carrying from 7 to 20 per cent boric acid. These beds have been mined for from 40 to 60 feet in width without reaching their limits, and are known to extend downward for over 200 feet in depth. In all probability, they will be found extending down below the limits of profitable extraction, the quantity being practically unlimited.

One of the interesting features of the Bartlett works is the brush piles for crystallizing the boric acid, the solution being pumped to the top of the piles. The photograph is self explanatory. The capacity of the works is about 30 tons of boric acid per month. This property is not controlled by the Borax Consolidated Ltd.

53 **The Columbia Mining and Chemical Co.**—Its works are located in the town of Daggett and are managed by Dr. F. Howard Humphries. The mines are located about six miles northwest of town.

The plant consists of boiling tanks, filter press, and evaporating and crystallizing tanks. (See photographs.) The ore is similar to that used by the Bartlett works. At the mine the shaft is run down about 200 feet, and cross-cuts have been made for over 100 feet without reaching the walls. The upturned edge of the bed has been traced for over two miles. The general dip is about 70 degrees to the north. Like the Bartlett ores, they are low-grade borates of lime, running from 7 to 20 per cent boric acid. The methods used are mentioned under the head of "Processes."

The boric acid made by both Humphries and Bartlett is exceptionally pure. The capacity of the works is about 30 tons of boric acid per month.

54 **The Oasis Mining and Oil Co.**—Of Barstow, California, is sinking a shaft on its borax claims about one and a half miles northwest of Marion, expecting to reach the bedded deposits below.

55 **Cave Springs.**—Borax deposits, consisting of borate of lime associated with carbonate of soda, salt, and sulphate of soda, have been recently located southeast of Cave Springs, near the Daggett road, but no development work has been done. It is reported that borate "mud beds" similar to those near Daggett have also been discovered in this district, which lies along the south flank of the Avawatz Mountains.

56 **China Lake.**—This playa lake lies partly in this county and partly in Kern County. (See "Kern County.")

57 **Coyote Holes, or Willow Springs Lake.**—The playa lake that lies about twenty miles northeast of Daggett is locally known as Coyote Holes, or Willow Springs, from the two springs on its north and south edges. It is situated in Township 11 North, Range 2 East, S. B. M. At Coyote Holes there is a "marsh" of about 300 acres that is surrounded by a crust of borax. The marsh itself is mainly a carbonate of

BORAX WORKS, SAN BERNARDINO COUNTY.

BORAX WORKS, SAN BERNARDINO COUNTY.

soda bed. The borax is mainly ulexite or "cotton ball" borax, and is undeveloped.

58 **Lone Star.**—Beds of colemanite have been recently discovered in the south flank of the Lone Star range, almost directly north of Leach's Spring, in Township 18 North, Range 2 East, S. B. M. These beds are from 3 to 5 feet thick, and outcrop for intervals for a distance of about two miles.

59 **Lone Willow.**—Outcrops of colemanite similar to those of Lone Star have been discovered this spring a few miles west of the Lone Willow Springs, in the south flank of Brown's Mountain. No development work has yet been done upon them.

60 **Lower Canon Beds.**—In the alternating strata of sedimentary beds in the Lower Cañon niter beds, situated in the cañon of the Amargosa River, evidence of the presence of borates has been found. Colemanite and ulexite have both been found as "float," and an examination of the numerous strata will in all probability show the existence of beds of commercial value.

61 **Mojave Sink.**—The sink of the Mojave River is situated in Townships 11 to 13 North, Ranges 8 and 9 East, S. B. M. Borax has been found in the playa layers of this lake, that is locally known as Soda Lake. It is associated with the carbonates and sulphate of soda, but no attempt has been made to explore the deposits to see if the borax exists in commercial quantities. Around Borax and Barrel Springs the borax is too spotted and in too small quantities to be of value. Borings might give waters carrying values.

62 **Owl Springs.**—The Owl Springs, or Owl Holes, are located in Township 18 North, Range 3 East, S. B. M. Priceite and colemanite both occur in large quantities at the niter beds of this district, associated with carbonate and sulphate of soda. Description of these beds is given under the head of "Niter."

63 **Palma Lake.**—Borax mixed with natural soda has recently been discovered six miles from Twenty-nine Palms. The deposits cover large portions of Sections 56, 29, 31, and 32, in Township 9 East, Range 2 North, S. B. M. The deposits are similar in many respects to the well-known Searles Lake. The property is being opened up by Messrs. Johnson & Williams, of Riverside.

64 **Pilot Beds.**—Borate deposits have been found recently at the south end of the Slate range, southeast of Searles Lake. These deposits are mainly borate of lime in strata underlying the niter beds. No work has as yet been done to show their extent and value. The property is in the hands of W. R. Fales, of Los Angeles.

65 **Salt Springs.**—These are located in Township 18 North, Range 7 East, S. B. M., on the south fork of Amargosa River. They form here a playa lake deposit of several hundred acres, similar to those already described at Coyote Holes, Owl Springs, and elsewhere.

66 **Saratoga Beds.**—These beds are located in Township 18 North, Range 5 East, S. B. M. They occupy the flats around Saratoga Springs, at the foot of Funeral range, in the bottom of the south end of Death Valley. Claims covering 5600 acres have been made on this portion of the bed of the ancient lake. The borax occurs around the springs and in the flat as a crust mixed with soda compounds. These crusts are from 1 to 3 feet deep, the richest borates being found in "pools" and "basins" varying from a few feet to several acres in extent, making the beds, as a whole, quite spotted, as all of the borax deposits are. Rich portions are also found along the shallow river channels that wind everywhere through the flats. Samples taken have varied from 7 to 40 per cent of borax; from 10 to 60 per cent of sulphate of soda; from a trace to 5 per cent of carbonate of soda; from 8 to 25 per cent of chloride of soda; and from 10 to 50 per cent of insoluble matter. There is present also more or less magnesia, and some iodine. Traces of boric acid were found in the Saratoga Springs, which are warm springs that issue with considerable force and in large volume from beneath the lavas. The overflow of these springs forms lakes that cover the greater portion of a section. It is probable that boring will reveal the presence of beds of borates, and waters rich in borax.

Besides in the beds around the springs, borax in considerable quantities has been found in the niter fields three miles south, along the flank of the Avawatz range, and is described under the head of "Niter."

67 **Searles Borax Lake.**—This deposit has figured on many maps under the names of "Dry Lake," "Alkali Flat," "Salt Bed," "Borax Marsh," "Searles Lake," etc. It is located near

the Inyo County line in Township 25 North, Range 43 West, M. D. M. The beds are of special interest, as the operations there in 1874, and for several years later, were the training school at which many leaders in later years studied the borates. The beds were discovered February 14, 1863, by Dennis Searles and E. M. Skillings, but work did not begin until 1874.

The San Bernardino Borax Mining Company was incorporated in 1878 to work these beds. The borax beds are near the center of a playa lake that is 10 miles long by 5 miles wide, situated 1700 feet above sea-level.

The portion productive of borax is an oblong area of about 1700 acres, slightly depressed below the general level of the playa. Water stands in this area to the depth of a foot in wet seasons. The old shore lines of this arm of Lake Aubury are distinctly to be seen on the slopes of the Slate and Argus ranges, some 600 feet above the playa lake, showing the different levels of the ancient lake.

The water on the beds is of a dark brown color, of 28 degrees density, Baumé. The mud below the water was full of large crystals, occurring in nests as in Lake County, at irregular intervals, to a depth of 3 or 4 feet. The natural crystals were of a green color, transparent, and often contained fluids in their large cavities. Curiously enough no ulexite or colemanite was ever found in this playa.

Thirteen tons of the crude material produced one ton of borax, equal to 7.69 per cent. The beds were not regular, but quite spotted in borax.

The associated minerals were anhydrite, calcite, celestite, cerargyrite, docomenite, embolite, gay-lussite, glauberite, gold, gypsum, halite, hanksite, natron, soda, niter, sulphur, thenardite, and trona; most of these occurring, however, in small quantities only.

Artesian water was obtained at a depth of 55 feet that rose 3 feet above the surface. The dry, hard playa crust, about one foot thick, was analyzed by C. N. Hake, as follows:

Sand	50.0
Soda sulphate	16.0
Salt	12.0
Soda carbonate	10.0
Borax	12.0
	100.0

The method of working was simple, consisting of scraping the crust into windrows, and then gathering by carts and taking it to the works two miles distant. It was noted here, in digging the crystals out of the mud, that the crystals grew. The holes left soon filled with water containing boric acid in solution; this, coming into contact with soda, formed crystals of biborate of soda (borax), which were deposited in the mud. Large vats were dug in the mud and brush thrown in for the crystals to form on. On ground that had been worked over, a new crust formed also that was thick enough to remove in three or four years. Such growths give the following analysis:

	6 Mos.	2 Yrs.	3 Yrs.	4 Yrs.
Sand	58.0	55.4	52.4	53.3
Soda carbonate	5.2	5.0	8.1	8.0
Soda sulphate	11.7	16.7	16.6	16.0
Soda chloride	10.9	10.0	11.1	11.8
Borax	14.2	12.9	11.8	10.9

It will be noted that the borax is richest at first, and that the sodas increase faster than the borax. The effect of the Æolian sands is especially noticeable.

These analyses throw considerable light upon the genesis of the deposits.

Borings made here in 1867 are of special interest in studying the genesis of the bottom of Lake Aubury:

(1.) 2 feet of salt and thenardite.

(2.) 2 feet of clay, volcanic sand, containing a few crystals and bunches of hanksite.

(3.) 8 feet of volcanic sand; black, tenacious clays, bunches of trona, black and shiny.

(4.) 8 feet of volcanic sand containing glauberite, thenardite, and a few crystals of hanksite.

(5.) 28 feet of solid trona (hydrous carbonate of soda) of fine quality.

(6.) 22 feet of black, slushy, soft mud, strong in hydrogen sulphide, with layers of glauberite, soda, and hanksite.

(7.) 230 feet of brown clay and volcanic mud, strongly impregnated with hydrogen sulphide.

Borings in other playa lakes would reveal strata similar in general to these. Compare also the "Order of Deposits" in the notes on Lake Aubury.

68 **Other Playa and Saline Lakes.**—There are many playa lakes in this county that contain borates in varying quantities, some

of them in commercial quantities; but the consolidation of interests at Calico by the large producers has checked all exploration of these deposits. The following list of the most prominent ones is given, not only for the sake of the record, but also to give a clearer idea of the extent of Lake Aubury, as these playas are all simply pools left in the desiccation of that great lake; and the history of one is the history of all, geologically.

In giving the meridian, S. B. M. means the San Bernardino meridian, and M. D. M. the Mount Diablo meridian.

AVAWATZ—T. 16 N., R. 4 E., S. B. M. San Bernardino County.

BALLARAT—T. 21, 22, 23 N., R. 44 E., M. D. M. Inyo County.

BRISTOL—T. 4, 5 N., R. 11, 12, 13, 14 N., S. B. M. San Bernardino County.

BUCKHORN—T. 9, 10 N., R. 9, 10 W., S. B. M. Kern County.

BURTS—T. 1 N., R. 12 E., S. B. M. San Bernardino County.

CACTUS—T. 15 S., R. 19 E., S. B. M. San Diego County.

CHINA—T. 25 S., R. 40, 41 E., M. D. M. Kern and San Bernardino Counties.

CRONESE—T. 12 N., R. 6 E., S. B. M. San Bernardino County.

COYOTE—T. 11, 12 N., R. 2 E., S. B. M. San Bernardino County.

DANBY—T. 1, 2 N., R. 17, 18, 19 E., S. B. M. San Bernardino County.

DEATH VALLEY—T. 23 to 27 N., R. 1 E., S. B. M. Inyo County.

FRANKLIN—T. 25 N., R. 5, 6 E., S. B. M. Inyo County.

HARPER—T. 11 S., R. 4 W., S. B. M. San Bernardino County.

IVANPAH—T. 15, 16, 17 N., R. 16 E., S. B. M. San Bernardino County.

KANE—T. 29, 30 S., R. 38, 39 E., M. D. M. Kern County.

LANDER—T. 26, 27 S., R. 40 E., M. D. M. Kern County.

LANGFORD—T. 13 N., R. 3, 4 E., S. B. M. San Bernardino County.

LAVIC—T. 7, 8 N., R. 5, 6 E., S. B. M. San Bernardino County.

MOJAVE—T. 6, 7 N., R. 4, 5 W., S. B. M. San Bernardino County.

SALT AND BORAX FLATS, DEATH VALLEY INYO COUNTY.

BORIC ACID WORKS—CRYSTALLIZING TANKS—BARTLETT WORKS, NEAR DAGGETT, SAN BERNARDINO COUNTY.

Mud Volcanoes—T. 10 S., R. 13 E., S. B. M. San Diego County.

Owens—T. 16, 17, 18 S., R. 36, 37, 38 E., M. D. M. Inyo County.

Rabbit—T. 4 N., R. 1 E., S. B. M. San Bernardino County.

Resting Springs—T. 21, 22, 23 N., R. 6, 7 E., S. B. M. Inyo County.

Rosamond—T. 9 N., R. 11, 12 W., S. B. M. Kern County.

Salton—T. 8, 9, 10, 11 S., R. 9, 10, 11, 12, 13 E., S. B. M. San Diego County.

Salt Marsh—T. 14 S., R. 38, 39 E., M. D. M. Inyo County.

Searles—T. 24, 25 S., R. 42 E., M. D. M. Inyo and San Bernardino Counties.

Soda—T. 11, 12, 13 N., R. 8, 9 E., S. B. M. San Bernardino County.

Tecopah—T. 20 N., R. 8, 9 E., S. B. M. Inyo County.

Willards—T. 30, 31 S., R. 42 E., M. D. M. San Bernardino County.

69 Unnamed Lakes.

No. 1—T. 16 N., R. 2 E., S. B. M. San Bernardino County.

No. 2—T. 16 N., R. 2 E., S. B. M. San Bernardino County.

No. 3—T. 14, 15 N., R. 1 E., S. B. M. San Bernardino County.

No. 4—T. 14 N., R. 3 E., S. B. M. San Bernardino County.

No. 5—T. 14 N., R. 6 E., S. B. M. San Bernardino County.

No. 6—T. 13 N., R. 6 E., S. B. M. San Bernardino County.

No. 7—T. 10 N., R. 2 W., S. B. M. San Bernardino County.

No. 8—T. 6, 7 N., R. 7 W., S. B. M. San Bernardino County.

No. 9—T. 2, 3 N., R. 14, 15, 16 E., S. B. M. San Bernardino County.

No. 10—T. 26 S., R. 42 E., M. D. M. San Bernardino County.

No. 11—T. 3 N., R. 8 E., S. B. M. San Bernardino County.

No. 12—T. 2 N., R. 9 E., S. B. M. San Bernardino County.

No. 13—T. 1 N., R. 9 E., S. B. M. San Bernardino County.

No. 14—T. 17 N., R. 2, 3 E., S. B. M. San Bernardino County.

No. 15—T. 4 N., R. 5, 6 E., S. B. M. San Bernardino County.

No. 16—T. 4 N., R. 4, 5 E., S. B. M. San Bernardino County.

No. 17—T. 5 N., R. 5 E., S. B. M. San Bernardino County.

No. 18—T. 31 S., R. 46 E., M. D. M. San Bernardino County.

No. 19—T. 31 S., R. 46 E., M. D. M. San Bernardino County.

No. 20—T. 31 S., R. 46 E., M. D. M. San Bernardino County.

No. 21—T. 8 N., R. 8 E., S. B. M. San Bernardino County.
No. 22—T. 6 S., R. 18, 19 E., S. B. M. Riverside County.
No. 23—T. 9 S., R. 6, 7 E., S. B. M. San Diego County.
No. 24—T. 12 S., R. 8 E., S. B. M. San Diego County.
No. 25—T. 12 S., R. 8 E., S. B. M. San Diego County.
No. 26—T. 18 S., R. 42 E., M. D. M. Inyo County.
No. 27—T. 9 N., R. 8 E., S. B. M. San Bernardino County.
No. 28—T. 6 N., R. 6 E., S. B. M. San Bernardino County.
No. 29—T. 6, 7 N., R. 9 W., S. B. M. Kern County.
No. 30—T. 9 N., R. 10 W., S. B. M. Kern County.

There are many other small ones not noted on any published maps or surveys.

70 TEHAMA COUNTY.

The first discovery of borax on the American continent was made in this county on January 8, 1856, by Dr. John A. Veatch. He identified the mineral while evaporating water from the "Tuscan Springs," which are also known as the "Lick Springs." Although several pounds were secured, and specimens were sent to the Academy of Sciences at San Francisco, no borax was produced of commercial value, as the amount present in the waters was too small to work. The springs where the discovery was made lie about eight miles east of Red Bluff. Free boric acid is found as an efflorescence around the springs.

While Tehama County has the honor of the discovery, no borax has been produced within her boundaries. Traces of the saline are common in the numerous salt springs along the east flank of the Coast Range in this and in Shasta County. These springs occur either in the sandstone, or in the magnesian limestone above it; and the presence of borates may be looked for if there are any indications of volcanic disturbances in the region of the spring. The presence of boric acid has also been found in the springs of Solano, Colusa, and other counties. (See "Springs Containing Borates.")

71 VENTURA COUNTY.

Large and valuable beds of colemanite are being worked in this county, and with the building of the railroad now in progress, the district will probably become a prominent producer, as the field is extensive and the beds of excellent value.

The beds were discovered in 1899, and the Stauffer Chemical Company, of San Francisco, has been the pioneer in this field. The company has located some 2000 acres in the Piru Mineral District, in Township 8 North, Ranges 21, 22 West, S. B. M. The croppings, however, are said to extend for eight miles over the mountains. The vein is 4 feet thick, the colemanite carrying 34 per cent of the anhydrate.

The beds are similar in their general features to those at Calico, except that here there are large beds of gypsum in the sedimentary strata above the borates. Although the crude material has to be hauled some sixty miles by wagon to Bakersfield, yet from 100 to 200 tons a month are mined and shipped to the Stauffer Chemical Works at San Francisco, or to the borax factory of T. Thorkildsens Co. at Chicago.

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72 SPRINGS CONTAINING BORATES.

While the presence of boric acid, and borates, in small quantities, in many of the well-known springs of the State is not of commercial importance, yet it shows the wide distribution of the mineral. Full investigation will probably extend the following list until nearly every county of the State is included, as the presence of boric acid, or its compounds, may be looked for wherever there are indications of volcanic disturbances in the region of the spring.

Alameda County.—Piedmont White Sulphur Springs: 1.90 to 5.23 grains in one U. S. gallon.

Butte County.—Mount Ida, four miles east of Oroville. Strong traces.

Colusa County.—Traces of borax in the salt springs on Stony Creek.

El Dorado County.—Glen Alpine Springs. Traces.

Humboldt County.—Eureka. Strong traces from a spring at the edge of the bay. This spring is reported as rich also in magnesia and lithia.

Lake County.—In addition to Borax Lake, already described, borax has been found in the Anderson, Bartlett, Harbin, Neptune, Diana, and Witter springs, and probably exists in many others not yet tested for it. (See "Register of Mines and Minerals of Lake County," California State Mining Bureau.)

GRANITE ELEPHANT, LEACH'S SPRING, SAN BERNARDINO COUNTY.

GRANITE WELLS, SAN BERNARDINO COUNTY. JOHNSON'S COPPER MINE. PILOT PEAK.

Mendocino County.—Borax spring one and one half miles from Hopland Station.

Mono County.—The waters of Mono Lake have been tested many times by chemists, who report all the way from traces to 19.75 grains per gallon. (See Mono County, under "Carbonates.")

Napa County.—Samuels Soda Spring. Traces.

Placer County.—Summit Soda Springs. Traces.

Santa Clara County.—Soda Springs, twelve miles east of Madrone. Traces.

San Luis Obispo County.—Santa Ysabel. El Paso de Robles Springs. Traces.

Shasta County.—Mouth of Pitt River. Common along Coast Range.

Solano County.—Lytton Springs, near Healdsburg. Traces.

Sonoma County.—Agua Rica Springs. Traces. White Sulphur Springs. Lytton Springs.

Tehama County.—Lick or Tuscan Springs. Borax first discovered here. Elevation, 925 feet. Springs cover an area of 10 acres in a basin of 600 acres. On an anticlinal axis, surrounded by volcanic bluffs. Temperature of water from 67° to 94°. Common in the springs along the Coast Range.

73 ## DESERT SPRINGS.

The following list of desert springs does not include those located at well-known mining camps and settlements. Many of the springs in the list are saline, and a few are so strongly impregnated with borax or other minerals as to make their waters unfit to drink. The list may aid prospectors and travelers in various ways. Additions and corrections should be sent to the State Mining Bureau, San Francisco. "S. B. M." means San Bernardino meridian, and "M. D. M." Mount Diablo meridian.

74 ### INYO COUNTY.

Arab—T. 19 S., R. 39 E., M. D. M. Coso Valley.

Bennett's Wells—T. 25 N., R. 1 E., S. B. M. Death Valley.

DEVIL'S ROCKING-CHAIR, MOUTH OF AMARGOSA CAÑON, SAN BERNARDINO COUNTY.

AT A DESERT OASIS

BIRD—T. 15 S., R. 41 E., M. D. M. Butte Valley.

BOILING—T. 21 N., R. 6 E., S. B. M. Amargosa Valley.

BOILING—T. 21 N., R. 7 E., S. B. M. Amargosa Valley.

CHINA RANCH—T. 20 N., R. 7 E., S. B. M. Amargosa Cañon.

COLD—T. 13 S., R. 39 E., M. D. M. Saline Valley.

CRYSTAL—T. 20 S., R. 39 E., M. D. M. Coso Valley.

EMIGRANT—T. 17 S., R. 46 E., M. D. M. Lost Valley.

FOUNTAIN—T. 28 N., R. 1 E., S. B. M. Lost Valley.

FRANKLIN WELLS—T. 26 N., R. 6 E., S. B. M. Amargosa Valley.

FRESH—T. 22 N., R. 6 E., S. B. M. Amargosa Valley.

FURNACE—T. 27 N., R. 2 E., S. B. M. Death Valley.

GREENLAND—T. 27 N., R. 1 E., S. B. M. Death Valley.

HORSES—T. 21 N., R. 9 E., S. B. M. Amargosa Valley. Also called Tule Spring.

HOT—T. 13 S., R. 39 E., M. D. M. Saline Valley.

INDIAN—T. 13 S., R. 43 E., M. D. M. Lost Valley.

LAGUNITA—T. 23 S., R. 38 E., M. D. M.

MESQUITE—T. 24 N., R. 1 E., S. B. M. Death Valley.

NILE—T. 22 S., R. 42 E., M. D. M. Panamint Valley.

(No name)—T. 14 S., R. 45 E., M. D. M. Lost Valley.

(No name)—T. 16 S., R. 46 E., M. D. M. Lost Valley.

(No name)—T. 17 S., R. 38 E., M. D. M. East side Owens Lake.

(No name)—T. 17 S., R. 43 E., M. D. M. Butte Valley.

(No name)—T. 22 S., R. 42 E., M. D. M. Panamint Valley.

(No name)—T. 15 S., R. 45 E., M. D. M. Lost Valley.

RESTING—T. 21 N., R. 8 E., S. B. M. Amargosa Valley.

ROSE—T. 21 S., R. 37 E., M. D. M. Owens Valley.

SALT—T. 26 N., R. 1 E., S. B. M. Death Valley.

SODA—T. 22 S., R. 44 E., M. D. M. Panamint Valley.

SULPHUR—T. 19 S., R. 44 E., M. D. M. Panamint Valley.

SUMMIT—T. 24 S., R. 43 E., M. D. M. Panamint Valley.

SURVEYOR'S—T. 15 S., R. 46 E., M. D. M. Lost Valley.

TECOPAH—T. 20 N., R. 9 E., S. B. M. Willow Creek Valley.

THREE SPRINGS—T. 18 S., R. 38 E., M. D. M. South end of Owens Lake.

TULE—T. 21 N., R. 9 E., S. B. M. Amargosa Valley. Also called Horses Spring.

TULE—T. 25 N., R. 1 E., S. B. M. Death Valley.

SARATOGA SPRINGS, DEATH VALLEY, SAN BERNARDINO COUNTY.

SARATOGA LAKES, DEATH VALLEY, SAN BERNARDINO COUNTY.

UNION—T. 14 S., R. 36 E., M. D. M. Owens Valley.

WATER STATION—T. 24 S., R. 43 E., M. D. M. Panamint Valley.

WILD ROSE—T. 19 S., R. 44 E., M. D. M. Panamint Valley.

WILSON'S WELL—T. 15 S., R. 43 E., M. D. M. Butte Valley.

75 KERN COUNTY.

BUCKHORN—T. 9 N., R. 9 W., S. B. M. Buckhorn Lake.

COW WELLS—T. 29 S., R. 39 E., M. D. M.

COYOTE—T. 27 S., R. 37 E., M. D. M.

DESERT STATION—T. 32 S., R. 37 E., M. D. M.

EL PASO WELLS—T. 28 S., R. 40 E., M. D. M.

FLOWING WELLS—T. 10 N., R. 8 W., S. B. M. Buckhorn Lake.

GRAPEVINE—T. 25 S., R. 38 E., M. D. M. Salt Wells Valley.

INDIAN—T. 9 N., R. 11 W., S. B. M.

INDIAN—T. 26 S., R. 38 E., M. D. M. Salt Wells Valley.

KANE—T. 30 S., R. 38 E., M. D. M. Kane Lake.

LANDER WELL—T. 27 S., R. 40 E., M. D. M. Salt Wells Valley.

MESQUITE—T. 30 S., R. 38 E., M. D. M. Kane Lake.

(No name)—T. 9 N., R. 9 W., S. B. M. Buckhorn Lake.

(No name)—T. 29 S., R. 36 E., M. D. M.

WATER STATION—T. 32 S., R. 36 E., M. D. M.

WILLOW—T. 10 N., R. 13 W., S. B. M.

76 RIVERSIDE COUNTY.

BOULDER CO. WELL—T. 5 S., R. 14 E., S. B. M.

BROWN'S WELL—T. 5 S., R. 16 E., S. B. M.

CAÑON—T. 7 S., R. 13 E., S. B. M.

CHUCKAWALLA—T. 8 S., R. 16 E., S. B. M.

COTTONWOOD—T. 5 S., R. 12 E., S. B. M.

GRANITE TANKS—T. 6 S., R. 16 E., S. B. M.

McCOY'S—T. 5 S., R. 20 E., S. B. M.

MULE—T. 8 S., R. 20 E., S. B. M.

(No name)—T. 7 S., R. 16 E., S. B. M.

(No name)—T. 7 S., R. 21 E., S. B. M.

(No name)—T. 8 S., R. 19 E., S. B. M.

PALEN'S WELL—T. 4 S., R. 16 E., S. B. M.

WATERFALL, AMARGOSA RIVER, INYO COUNTY.

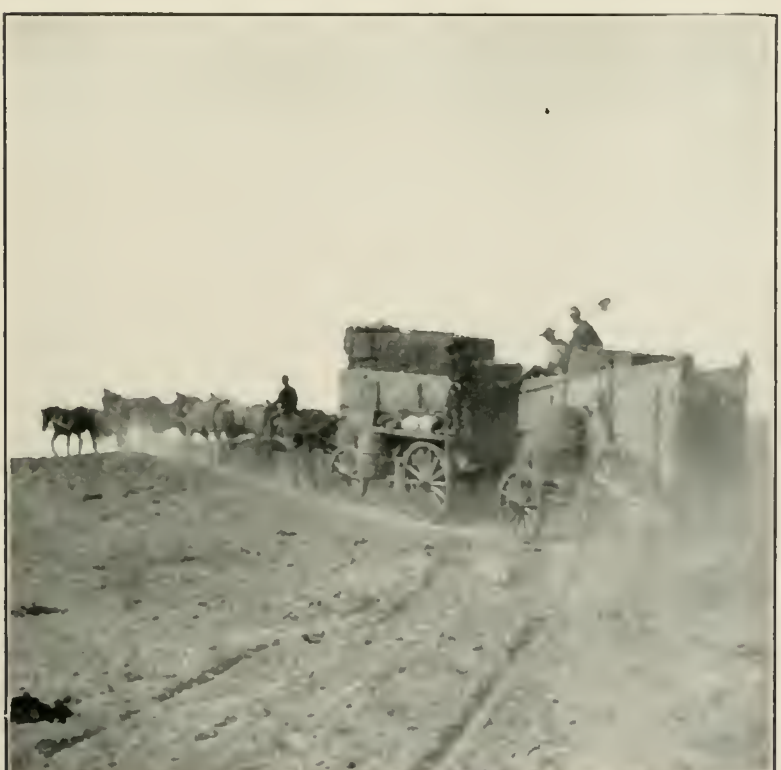
DESERT CACTUS.

Smith—T. 2 S., R. 7 E., S. B. M.
Stubbs—T. 2 S., R. 7 E., S. B. M.
Sulphur—T. 7 S., R. 10 E., S. B. M.

77 SAN BERNARDINO COUNTY.

Barrel—T. 12 N., R. 8 E., S. B. M. Soda Lake.
Bedrock—T. 28 S., R. 41 E., M. D. M. Lava Mountains.
Bitter—T. 13 N., R. 5 E., S. B. M.
Black—T. 11 N., R. 3 W., S. B. M.
Blackwater—T. 30 S., R. 43 E., M. D. M. Pilot Peak.
Bonanza—T. 7 N., R. 15 E., S. B. M. Clipper Mountains.
Borax—T. 12 N., R. 9 E., S. B. M. Soda Lake.
Burt's Well—T. 1 N., R. 12 E., S. B. M.
Cave—T. 17 N., R. 5 E., S. B. M. Avawatz Mountains.
City—T. 30 S., R. 41 E., M. D. M. Five miles east of Johannesburg.
Cooley's Well—T. 1 N., R. 18 E., S. B. M. Danby Lake.
Copper—T. 4 N., R. 2 E., S. B. M.
Cottonwood—T. 9 N., R. 13 E., S. B. M. Granite Mountains.
Cove—T. 8 N., R. 13 E., S. B. M.
Coyote Holes—T. 1 N., R. 7 E., S. B. M.
Coyote Holes—T. 11 N., R. 2 E., S. B. M. Coyote Lake.
Coyote Holes—T. 18 N., R. 10 E., S. B. M.
Cronese—T. 12 N., R. 6 E., S. B. M. Cronese Lake.
Fenner—T. 8 N., R. 18 E., S. B. M. Piute Mountains.
Fourth of July—T. 18 N., R. 2 E., S. B. M. Brown Mountain.
Francis—T. 15 N., R. 11 E., S. B. M.
Fresh—T. 14 N., R. 11 E., S. B. M.
Garlic—T. 13 N., R. 3 E., S. B. M.
Government Holes—T. 12 N., R. 16 E., S. B. M.
Government Wells—T. 12 N., R. 8 E., S. B. M. Soda Lake.
Granite Wells—T. 29 S., R. 44 E., M. D. M. Pilot Peak.
Grant—T. 11 N., R. 3 W., S. B. M.
Halloran—T. 14 N., R. 10 E., S. B. M.
Hidden—T. 18 N., R. 1 E., S. B. M. Brown Mountain.
Horse Thief—T. 19 N., R. 11 E., S. B. M. Kingston Mountains.
Indian—T. 30 S., R. 47 E., M. D. M.

THE DEAD BURRO DEATH VALLEY.



MINING BUREAU EXPEDITION.

Kane—T. 8 N., R. 3 E., S. B. M.

Kessler—T. 14 N., R. 14 E., S. B. M.

Langford Well—T. 13 N., R. 3 E., S. B. M.

Leach's—T. 17 N., R. 2 E., S. B. M. Leach's Mountain.

Lead—T. 28 S., R. 46 E., M. D. M.

Lone Star—T. 18 N., R. 2 E., S. B. M. Brown Mountain.

Lone Willow—T. 26 S., R. 46 E., M. D. M. Brown Mountain.

Lyons Well—T. 1 N., R. 11 E., S. B. M.

Marl—T. 12 N., R. 13 E., S. B. M.

Mean's Well—T. 4 N., R. 4 E., S. B. M.

Mesquite—T. 2 N., R. 8 E., S. B. M.

(No name)—T. 1 N., R. 21 E., S. B. M.

(No name)—T. 4 N., R. 1 W., S. B. M.

(No name)—T. 6 N., R. 2 E., S. B. M. Ord Mountain.

(No name)—T. 12 N., R. 2 E., S. B. M.

(No name)—T. 13 N., R. 12 E., S. B. M.

(No name)—T. 16 N., R. 4 E., S. B. M.

(No name)—T. 17 N., R. 11 E., S. B. M.

(No name)—T. 30 S., R. 45 E., M. D. M.

Owl—T. 18 N., R. 3 E., S. B. M. Death Valley.

Old Woman—T. 3 N., R. 3 E., S. B. M.

Old Woman—T. 5 N., R. 18 E., S. B. M. Old Woman Mountain.

Paradise—T. 12 N., R. 1 E., S. B. M.

Pass—T. 13 N., R. 15 E., S. B. M. Providence Mountains.

Pilot—T. 29 S., R. 44 E., M. D. M. Pilot Peak.

Piute—T. 12 N., R. 18 E., S. B. M.

Providence—T. 9 N., R. 14 E., S. B. M. Providence Mountains.

Quail—T. 18 N., R. 2 E., S. B. M. Brown Mountain.

Quail—T. 28 S., R. 41 E., M. D. M. Lava Mountains.

Rabbit—T. 4 N., R. 1 W., S. B. M.

Rock—T. 11 N., R. 15 E., S. B. M.

Rock—T. 12 N., R. 16 E., S. B. M.

Rock Corral—T. 3 N., R. 5 E., S. B. M.

Saratoga—T. 18 N., R. 5 E., S. B. M. Death Valley.

Salt—T. 18 N., R. 7 E., S. B. M. Death Valley.

Salt—T. 19 N., R. 4 E., S. B. M. Death Valley.

Squaw—T. 30 S., R. 42 E., M. D. M.

Star—T. 32 S., R. 43 E., M. D. M.

Stoddard's Wells—T. 7 N., R. 2 W., S. B. M.

GYPSUM VEIN, AMARGOSA RIVER, SAN BERNARDINO COUNTY.

EOCENE BLUFFS, WILLOW CREEK, INYO COUNTY.

SULPHUR—T. 2 N., R. 8 E., S. B. M.
SURPRISE—T. 3 N., R. 7 E., S. B. M.
VALLEY—T. 16 N., R. 13 E., S. B. M. Clark's Mountain.
WARM—T. 9 N., R. 3 E., S. B. M. Newberry Mountain.
WARNER'S WELL—T. 1 N., R. 5 E., S. B. M.
WATER TANK—T. 11 N., R. 18 E., S. B. M.
WELL—T. 10 N., R. 7 W., S. B. M.
WELL—T. 11 N., R. 8 E., S. B. M. Soda Lake.
WILBUR'S WELL—T. 3 N., R. 5 E., S. B. M.
WILLARD'S WELLS—T. 30 S., R. 42 E., M. D. M.
WILLOW—T. 6 N., R. 2 E., S. B. M. Ord Mountain.
WILLOW—T. 8 N., R. 12 E., S. B. M.
WILLOW—T. 12 N., R. 2 E., S. B. M. Coyote Lake.
WILLOW—T. 27 S., R. 41 E., M. D. M.

78 SAN DIEGO COUNTY.

BOREGO—Sec. 17, T. 11 S., R. 7 E., S. B. M.
BOWERS—Sec. 22, T. 10 S., R. 9 E., S. B. M.
COYOTE WELLS—Sec. 29, T. 16 S., R. 10 E., S. B. M.
FISH—T. 9 S., R. 9 E., S. B. M. Salton Sea.
FISH BOILING SPRING—Sec. 26, T. 12 S., R. 7 E., S. B. M.
FRINKS—T. 9 S., R. 13 E., S. B. M.
INDIAN WELLS—T. 16 S., R. 13 E., S. B. M.
MCCAIN—Sec. 18, T. 11 S., R. 10 E., S. B. M.
MESQUITE OIL CO. WELL—Sec. 26, T. 12 S., R. 7 E., S. B. M.
MT. PALM—T. 10 S., R. 8 E., S. B. M.
MUD—Sec. 5, T. 10 S., R. 9 E., S. B. M.
(No name)—Sec. 1, T. 11 S., R. 10 E., S. B. M.
(No name)—Sec. 22, T. 11 S., R. 10 E., S. B. M.
(No name)—Sec. 28, T. 11 S., R. 10 E., S. B. M.
(No name)—Sec. 35, T. 10 S., R. 10 E., S. B. M.
(No name)—T. 9 S., R. 7 E., S. B. M.
PALM—T. 10 S., R. 9 E., S. B. M.
SACKETT'S WELL—T. 15 S., R. 11 E., S. B. M.
SODA—Sec. 7, T. 11 S., R. 10 E., S. B. M.
SODA—T. 12 S., R. 12 E., S. B. M.
SODA—Sec. 36, T. 10 S., R. 9 E., S. B. M.
SEVENTEEN PALMS—Sec. 35, T. 10 S., R. 8 E., S. B. M.
TULE—T. 11 S., R. 10 E., S. B. M.
YUCCA—Sec. 8, T. 17 S., R. 11 E., S. B. M.
ZACATAN—Sec. 8, T. 11 S., R. 9 E., S. B. M.

79 PROCESSES OF MANUFACTURE.

Progress in the processes of manufacture has kept up with the constantly increasing demand for borax at a low price. This is shown by comparing the methods at Borax Lake, in Lake County, in 1864, and at the huge works at Bayonne, New Jersey, that handle the crude material from this State.

Every year has seen some improvement made in the industry in the way of more perfect appliances and processes. The process at first used in Lake County consisted in boiling the borax and crystallizing it in small pans holding from 2 to 3 gallons each; and the plant that produced the first 12 tons in 1864 consisted of some 4000 such pans. The processes at the period when the "marsh" beds were worked consisted of boiling the crude material in large iron tanks and then running the solution into wood or iron settling tanks, the crude borax obtained being purified by re-crystallization.

In the Calico district the colemanite ore is treated as follows at Marion: Low-grade ores, that were formerly rejected, are roasted in a Holthoff-Withey furnace, with two hearths having a capacity of 100 tons a day, six oil burners furnishing the heat. Colemanite when mildly heated is reduced to a fine powder, which is bolted, sacked, and shipped to the company's works at Bayonne, New Jersey, where the "flour" is boiled with soda to form borax. Any pandermite ore present is not affected by the heat and is lost in the waste, known locally as "dry bone." This waste often amounts to 50 per cent of the "flour" secured.

At Bayonne the huge machinery is driven by sets of independent electric motors. The crude colemanite reaches the works in sacks, as shipped from this State. It is first coarse-crushed on the ground floor of the works, and then conveyed to a Griffin mill, which reduces it to the fineness of flour. It is then carried by a screw conveyor to the foot of an elevator, which raises it to the first floor. Here it is dropped into a 100-ton tank and boiled with water. After boiling, it is drawn into settling tanks on the second floor, where the clear solution is run back to crystallizing vats on the first floor, the sediment being raised by a centrifugal pump to a tank on the third floor, and thence into a filter press of 50 pounds per square inch, the pulp receiving finally, however, double that pressure.

The liquor drawn from the press goes back to the settling tank, and the refuse cakes go to the dump.

The crystallizing vats are of sheet iron 20 feet long, by 6 feet wide and 6½ feet deep. Two-inch iron pipes are laid across the top of the vats, from which wires 5 feet long and 0.25 inch in diameter hang into the vats. As the solution cools, the borax crystallizes upon the wires and on the sides and bottoms of the vats. After crystallization, the mother liquor is pumped out and used again as a solvent, and the borax crystals removed. The crystallized borax is raised to the fourth floor to crushing rolls and screens and sorted into three sizes, viz: (1) Refined crystals; (2) Refined screenings; (3) Granulated borax. The granulated borax is then dried by hot air, in an inclined rotary cylinder; then pulverized in a Cyclone pulverizer; then caught in dust chambers; and finally barreled for the market.

It is found that while the borax from the wires in the vat is pure, that from the sides and bottom has to be re-dissolved and refined.

80 **Chlorine Process.**—This process, used to some extent in England, is sometimes known as the "Moore Process." The powdered crude colemanite is suspended in water and heated to 70° C. while chlorine gas is passed in; the gas is quickly absorbed, liberating boric acid, and forming calcium chloride and chlorate. On cooling, most of the boric acid crystallizes out and is purified by re-crystallization. The mother liquor is used again and again until the alkali salts have accumulated sufficiently in it to separate.

81 **Hydrochloric Acid Process.**—The calcium borate is treated with 2 parts of the hydrochloric acid by weight, and 4 parts of water, and boiled until digested, the water that evaporates being replaced. The liquor is then drawn off, and, on cooling, the boric acid crystallizes out, the sodium and calcium chloride remaining. The boric acid crystals are drained, pressed, whizzed, washed with cold water, and whizzed again.

82 **Sulphuric Acid Process.**—In this, the borate of lime is treated with sulphuric acid, and the boric acid formed is dissolved out with hot water, the liquor drawn off, and evaporated to crystallization.

At Calico a modification of this process is used, the borate mud being boiled in huge tanks with sulphur. The borate of lime is broken up, the boric acid being set free and going into solution; the lime being converted into insoluble sulphate of lime. The mother liquor is drawn off and the boric acid is obtained by fractional crystallization. Filter presses are used at the works of the Columbia Company, but not at the Bartlett works.

83 **Ammonia Process.**—Boric acid is made, by the Bigot method, by treating 100 parts of colemanite with 150 parts of ammonium sulphate, by heating in a closed vessel. Ammonium borate is formed at first, which then splits up into boric acid and ammonia. The ammonia is condensed and collected.

The boric acid is dissolved out of the residue with water, concentrated and crystallized.

84 **Borax from Boric Acid.**—To prepare borax from the acid, 110 to 120 parts of crystallized sodium carbonate is dissolved in a lead-lined vessel, heated by steam; and 100 parts of boric acid added cautiously to the closed vessel.

Another method is to prepare the solutions in the proportion of two molecules of ammonia and one molecule of sodium nitrate to two molecules of boric acid. The mixture is heated, and dissolved in the minimum amount of water. Biborate of soda (borax) and ammonium nitrate are formed.

The borax factory at Alameda, California, until the erection of the works at Bayonne, New Jersey, and the formation of the Borax Consolidated Ltd., handled all of the material mined at Calico.

The works consist of three buildings, each three stories high; one part is concrete and measures 40 x 230 feet; another is frame, 80 x 170 feet; and the third is 26 x 110 feet; there is also a one-story building, 80 x 145 feet; and a shed 30 x 110 feet.

The process there was as follows: The crude colemanite was broken to nut size by a Blake crusher; then it passed to the grinding mill, where it was reduced to sand; then to rolls that left the material as fine as flour. The floured borate was then mixed with carbonate of soda from Owens Lake, and the two boiled in an iron tank, where it was thoroughly stirred by an agitator.

The carbonate of soda and borate of lime were broken up, the reaction forming insoluble carbonate of lime and soluble biborate of soda, or borax. The solution of borax was drawn off into tanks, where it crystallized in dark crystals, the mother liquor being drawn off and used over again in boiling more of the crude material. The sediments in the boiler were washed several times and then put through a filter press. The impure crystals of borax were dissolved in tanks of hot water, and the solution run into crystallizing vats, in which wires were suspended. The borax crystallized on the wires and on the sides and bottoms of the tanks, that on the wires being the purest. After crystallization the borax was ground and sorted by sifting for the market.

85
MINERALOGY.

BORAX MINERALS, AND THOSE CONTAINING BORIC ACID IN SMALL QUANTITIES.

86 **Nordenskioldine.**—A borate of lime and tin. Boric acid, 25.1; tin oxide, 54.5; lime, 20.4. Color, sulphur-yellow. Brittle. Hardness, 5.5 to 6. Gravity, 4.2. Rare.

87 **Jeremejevite.** — Borate of aluminum. Boric acid, 40.6; alumina, 59.4. Colorless to pale yellow. Hardness, 6.5. Gravity, 3.2.

88 **Sussexite.**—A borate of manganese and magnesia. Boric acid, 34.1; manganese, 41.5; magnesia, 15.6. Color, white, with tinge of pink or yellow. Hardness, 3. Gravity, 3.4.

89 **Ludwigite.**—A borate of iron and magnesia. Boric acid, 16.6; iron, 54.9; magnesia, 28.5. Color, blackish green to black. Hardness, 5. Gravity, 3.9 to 4.0.

90 **Pinakiolite.**—A borate of manganese and magnesia. Boric acid, 16.7; manganese, 54.6; magnesia, 28.7. Color, black. Hardness, 6. Gravity, 3.8.

91 **Hambergite.** — A borate of beryllium. Boric acid, 37.1; beryllium, 53.3. Color, gray-white. Hardness, 7.5. Gravity, 2.3.

92 **Sizabelyite.** — Borate of magnesia. Boric acid, 38.1; magnesia, 54.5. Color, white outside, yellow within. Hardness,

3 to 4. Gravity, 3. Of special interest because it occurs in limestone, and gives weight to the theory that rock formations carry borax minerals in large quantities.

93 **Boracite.** — Borate of magnesia. Boric acid, 62.5; magnesia, 31.4; chlorine, 7.9. Color, white to gray, yellow and green. Hardness, 7. Gravity, 2.9. The massive variety resembles fine-grained marble.

94 **Rhodizite.**—A borate of aluminum and potassium. Boric acid, 33.93; aluminum, 41.4; potassium, 12.0. Color, white, translucent. Hardness, 8. Gravity, 3.3 to 3.4. Contains also cæsium and rubidum. Rare.

95 **Warwickite.**—A borate and titanate of iron and magnesia. Boric acid, 27.80; titanic acid, 23.82; magnesia, 36.80; iron, 7.02. Color, dark brown to black. Hardness, 3 to 4. Gravity, 3.5. Found in limestone in New York. Rare.

96 **Howlite.**—A silico-borate of lime. Silica, 15.3; boric acid, 44.6; lime, 28.6. Color, white. Hardness, 3.5 or less. Gravity, 2.55. Occurs in scales in gypsum nodules.

97 **Lagonite.**—Borate of iron. Boric acid, 48.5; iron, 37.8. Color, ochre yellow, occurring as an incrustation. Earthy.

98 **Larderellite.**—Borate of ammonium. Boric acid, 69.2; ammonia, 12.9. Color, very light white to yellow. Occurs in small crystalline plates. Rare.

99 **Colemanite.**—Borate of lime. One of the most important sources of borax and boric acid in California. Boric acid, 50.9; lime, 27.2. Colorless to milky white, yellowish white, and gray. Transparent to translucent. Hardness, 4 to 4.5. Specific gravity, 2.417. Crystals monoclinic. Soluble in hot hydrochloric acid, with separation of boric acid crystals on cooling. In the blowpipe it decrepitates, exfoliates, sinters, and fuses imperfectly, coloring the flame yellowish green. Various analyses of the California mineral show the following:

Boron trioxide...	48.12	47.64	49.70	50.70	49.59
Lime	28.43	27.97	27.42	27.31	27.38
Water.........	22.20	22.79	22.26	21.87	22.68

The analyses also show traces of aluminum, iron, silica, and magnesia, according to the locality from which the samples come.

The mineral was first discovered in Death Valley, in Inyo County, in October, 1882, and was first analyzed by Thomas Price, of San Francisco, in March, 1883. The mineral was named in honor of William T. Coleman, of San Francisco, who was identified with the borax industry from its beginning in the State.

Occurs in beds in Inyo County, at Monte Blanco, Furnace Creek, Upper Cañon beds, and Confidence niter beds; in San Bernardino County, at Calico district, Lower Cañon niter beds, Saratoga niter beds, Owl Springs niter beds, and Valley niter beds; in Ventura County, at the Stauffer mines, and elsewhere.

100 **Priceite.**—A variety of Colemanite. A hydrous borate of lime. Boric acid, 48.7; lime, 32.5; water, 18.8. A soft, chalky mineral first discovered in October, 1871, by Lieutenant A. W. Chase, and first analyzed by Thomas Price, of San Francisco. Common in Death Valley, Inyo County, and in the playa beds of Kern and San Bernardino counties.

101 **Pandermite.**—A variety of Priceite. Dana says that Priceite and Pandermite are obviously identical, and may represent a not entirely pure variety of colemanite.

102 **Pinnoite.**—A hydrous magnesium borate. Boric acid, 42.6; magnesia, 24.4; water, 33.0. Usually in nodules, with radiated fibrous structure. Color, sulphur or straw yellow to pistachio green. Hardness, 3 to 4. Gravity, 3.27.

103 **Heintzite.**—A hydrous borate of magnesium and potassium. Rare.

104 **Borax.**—Native borax or biborate of soda. One of the main sources of borax in the State. Boric acid, 36.6; soda, 16.2; water, 47.2. Color, white; sometimes grayish, bluish, or greenish. Hardness, 2 to 2.5. Specific gravity, 1.69 to 1.72. Luster, vitreous to resinous, sometimes earthy. Translucent to opaque. Taste, sweetish alkaline, feeble. Soluble in water. In blowpipe fuses to "borax glass."

Known also as *Tincal*. The purest natural crystals ever discovered were those from the Borax Lake, in Lake County, which were 99.94 per cent pure. The celebrated Searles marsh in San Bernardino County had large transparent crystals, that inclosed fluids in their large cavities. Borax in a pulverulent form is common in the "marshes," "dry lakes," or playa lakes of Inyo, San Bernardino, Kern, and Riverside counties.

105 **Tincalonite.**—A pulverulent and efflorescent variety of borax, containing 32 per cent of water.

106 **Ulexite.**—A hydrous borate of sodium and lime. A valuable source of borax in California and Nevada. Boric acid, 43.0; lime, 13.8; soda, 7.7; water, 35.5. Color, white. Tasteless. Hardness, 1. Gravity, 1.65. Occurs usually in rounded masses, loose in texture, and consisting of fine, silky fibers. Locally known to the miners as "cotton balls," occurring in rounded concretions from the size of a pea to over a foot in diameter.

Synonyms: Borate of lime, tiza, cotton balls, sheet cotton, etc. Found as "sheet cotton" at Furnace Creek, Death Valley, Inyo County; and at Desert Springs, Kern County. Found as "cotton balls" at Resting Springs, Tecopah, Upper Cañon Beds, Monte Blanco, and Confidence Beds, in Inyo County; and at Searles Lake, Calico District, Owl Springs, Saratoga Springs, Salt Springs, etc., in San Bernardino County; and at Mesquite Springs, Kern County.

107 **Hayesene.**—Obsolete name for ulexite.

108 **Franklandite.**—A massive variety of ulexite with fine fibrous structure.

109 **Cryptomorphite.**—A variety of ulexite occurring in dull, white kernels. Boric acid, 59.10; lime, 15.55; soda, 5.61; water, 19.72.

110 **Bechilite.**—Hydrous borate of lime. Boric acid, 51.14; lime, 20.85; water, 26.25. Occurs in crusts as a deposit from springs.

111 **Hydroboracite.**—A borate of lime and magnesia. Boric acid, 49.58; lime, 13.52; magnesia, 10.57; water, 26.33. Resembles fibrous and foliated gypsum. Hardness, 2. Gravity, 1.9. Distinguished from gypsum by its fusibility.

112 **Sassolite.**—Boric acid. Native boric acid is common in the springs of the State, as mentioned elsewhere.

113 **Danburite.**—This is a silicate of lime, containing 22 per cent of boric acid. It was discovered in dolomite in the East,

and shows the wide distribution of boric acid in the rock formations of the earth.

114 **Datolite.**—A silicate of lime containing 21 per cent of boric acid. Found in trap rocks and may be one of the subterranean sources of boric acid in springs.

115 **Tourmaline.**—The tourmaline series of minerals all contain from 3 to 10 per cent of boric acid, and may be one of the sources from which the springs obtain their boric acid.

116 **Axinite.**—A boro-silicate of lime and aluminum found in granites, and a possible source of boric acid.

It will be seen from this list that the principal sources of borax in this State are the minerals colemanite, borax, and ulexite.

It is probable that many others of the minerals given exist in the California fields, but have not yet been identified. The presence of so many silicates, and of magnesium, indicates the presence of many of the minerals in the list above. A number of the rarer minerals given, such as szaibelyite, warwickite, danburite, etc., indicate the sources from which the hot springs have drawn their supplies of boric acid.

Silicoborates of lime probably exist in many localities as yet unsuspected by the prospector.

Those interested in the composition of the natural borates and borosilicates will find much information in a paper entitled "Analyses of Natural Borates and Borosilicates," by J. E. Whitfield, published in Bulletin No. 42, U. S. Geological Survey, 1889, Washington, D. C.

PART III.

CARBONATES.

117 "NATURAL SODA."

Natural soda is the residue obtained by the evaporation of the waters of an alkali lake, or the "sodas" dug up from the "dry lakes" of the desert. It is composed of sodium carbonate and bicarbonate, in varying proportions, mixed with impurities, the impurities consisting of three classes: (1st) When mixed with sodium chloride and sulphate; (2d) with sodium chloride and biborate; (3d) with sodium chloride and nitrate.

The first class is known locally as "soda, or salt, beds," the second as "borax beds," and the third as "niter beds."

Sodium carbonate, or monocarbonate (Na_2CO_3), is an opaque white salt of a specific gravity of 2.5. From its solution in water, it crystallizes with 1, 2, 3, 5, 7, 10, and 15 molecules of water; (1) according to the temperature of the solution, and (2) according to its exposure to the air while cooling.

The natural sodas gathered from different localities vary widely in composition, so that a process of manufacture developed in one locality and yielding there a cheap and pure product, may fail completely in another locality. This fact alone removes these salines from the list of "poor man's mines," as they require extensive plants, technical skill of high order, and ample capital to be successful.

The means employed, in general, are solution, evaporation, and fractional crystallization. By fractional crystallization is meant a methodical stoppage of the crystallizing process by removal of the remaining solution, or "mother liquor," from the "crop" of crystal so far obtained, a close watch of the temperature, density, and composition of the solutions being essential to success. Those interested in the technology of the natural sodas are referred to the admirable work by George Lunge, Ph.D., entitled "Sulphuric Acid and Alkali," 3 vols., London, 1880; to the reports of Professor Chatard, in Bulletin No. 60, U. S. Geological Survey, Washington, D. C., 1887; and to "Mineral Industries of the United States," Rothwell, 1898.

118 **Origin of Natural Sodas.**—Where a body of water has no outlet, it represents a simple concentration of the inflowing streams; and if the lake contains any given saline, then this saline has either been brought as such into the basin, or it is the result, or product, of chemical reactions among the constituents of the lake water. If the saline has been brought in as such, it is a product leached from the rocks or soils of the region, no matter whether the waters came from deep fissure springs or from surface drainage.

Springs carrying sodium carbonate are so numerous that to give the list would be to name most of the springs of the State. The sodium carbonate in such springs comes from the decomposition of the alkali-bearing rocks through which the water flows; and this decomposition is brought about by the combined action of air, moisture, heat, and pressure.

The salts of sodium are more common in the springs and lakes than the salts of potassium, because the soda minerals are more easily decomposable, and because soils have a strong tendency to take up and retain potash salts, while giving up soda salts readily.

The hot springs so common along the Sierras, the evidences of comparatively recent volcanic action, show that the western rim of the Great Basin has been the scene of remarkable activity in rock decomposition, the results of which were leached into Lake Aubury.

Where a solution, from a spring, or from surface leaching, that contains sodium chloride, sodium sulphate, and sodium carbonate, reaches an inclosed basin the percentage of natural soda will increase, the reason being that the sulphate is reduced by organic matter, and the carbonic acid in the atmosphere reacts upon the sulphide formed. Such a reaction requires a long period of comparative rest, a condition met in the formation of all the playa lakes of the desert. The subsequent local chemical changes, such as those due to boric acid coming into such lakes, have already been noted.

OWENS LAKE, INYO COUNTY.

SODA WORKS OWENS LAKE, INYO COUNTY.

INYO COUNTY.

119 **Owens Lake.**—The most important source of natural soda in this State is Owens Lake, both on account of its magnitude and of the facilities there for carrying on extensive operations. The lake lies between the Sierra Nevada on the west and the Inyo range on the east, and has no outlet, the pass to the south being 50 feet higher than the present level of the lake. Several small streams from the Sierras reach the lake, but the principal source of supply is Owens River, which is about 30 feet wide, 2 feet deep, and has a velocity of about 5 miles per hour. The shores are extensive, bare sandy flats, with areas covered with a strong growth of salt grass.

The waters of the lake contain large quantities of an "algous or fungoid plant, floating in small globular masses of a whitish or yellowish green," which collects in patches and becomes black from clouds of "alkali flies," or ephydra. In addition to the larvæ of the flies, the water swarms with the small crustacean *Artemia salina*, known locally as the "alkali shrimp."

Owens Lake is similar in its geological history to Mono Lake, which is described elsewhere (see page 98), and the two lakes, partially evaporated, are object lessons, showing the condition that Death Valley and the host of playa lakes of the desert were once in.

The phenomena now to be observed at either lake are similar to what primitive man might have seen along the shores of Searles Lake, or any of the other lakes of the Great Basin, when they were partially evaporated.

Owens Lake has at the present time no outlet. Its ancient shore lines, 190 feet above the present level, indicate that it at one time had an outlet to the south, and joined itself to the chain of lakes formed during the desiccation of Lake Aubury. The lake has an average depth of about 40 feet, and an area of 100 square miles.

The waters of the lake are strongly saline, the principal minerals being chloride of sodium and carbonate of sodium, the presence of the large amounts of carbonate being due to the volcanic material within its watershed.

A number of analyses, more or less complete, have been made of its waters, which vary according to the conditions under which they were made. The diluting of the waters after storms in the adjacent mountains, or their concentration at the end of a hot summer, is sufficient to explain any differences in the analyses.

One of the earlier analyses was the one made by Professor Phillips, of England, which was as follows:

	Grains per Gallon.
Sodium chloride	2,942.15
Sodium sulphate	956.80
Sodium carbonate	2,914.43
Potassium sulphate	35.74
Potassium silicate	139.54
Organic matter	16.95

The following analyses are comparatively recent, and were both made by members of the U. S. Geological Survey; No. 1 being by T. M. Chatard, and No. 2 by Oscar Loew:

	No. 1.	No. 2.
	Grains per Litre.	
Silica	0.220	0.1721
Iron and alumina	.038	......
Calcium carbonate	.055	.....
Magnesium carbonate	.479	...
Potassium chloride	3.137	.....
Sodium chloride	29.415	23.2830
Sodium sulphate	11.080	9.2907
Sodium carbonate	26.963	24.4080
Sodium bicarbonate	5.725	......
Potassium sulphate	......	6.4487
Total	77.112	63.6025

Another analysis is as follows:

	Per Cent.
Silica	.28
Iron, alumina, lime, magnesia	.13
Sodium biborate (borax)	.63
Potassium chloride	4.07
Sodium chloride (salt)	38.16
Sodium sulphate	14.38
Sodium carbonate	34.95
Sodium bicarbonate	7.40
	100.00

The waters also contain small quantities per litre of lithium, phosphoric acid, and nitric acid. The specific gravity is 1.051.

Analyses of the crude soda formed by solar evaporation, and fractional crystallization under varying conditions, gave Professor Chatard the following results:

	1	2	3	4	5	6
Water	20.87	14.51	4.33	3.43	2.24	11.03
Insoluble	1.55	.07	.....	.....	.....	.....
Organic silica, alumina, lime, and magnesia	.37	.09	.09	.06	.06	.18
Potassium chloride	.51	1.07	1.12	1.14	1.21	2.93
Sodium chloride	3.51	7.44	35.06	45.59	60.99	19.16
Sodium sulphate	1.89	3.18	25.44	26.70	19.01	5.70
Sodium carbonate	40.87	43.75	22.84	18.19	12.51	55.04
Sodium bicarbonate	30.65	30.12	10.53	4.06	3.88	4.09
Sodium biborate	.....	.....	.....	.....	.....	2.01
	100.22	100.23	99.41	99.17	99.90	100.14

The evaporation of these waters by solar heat divides them into three stages: first, the deposition of a comparatively pure compound of carbonate and bicarbonate of soda (see analysis 1); second, the formation of a product consisting in great part of sulphates and chlorides (analysis 5); and, third, the production of a mother liquor rich in carbonate of soda (analysis 6), but requiring an artificial heat for its further evaporation. This mother liquor contains the bulk of the potash and the boric acid of the original waters.

From the analyses, and from data similar to that quoted in connection with Mono Lake, it is estimated by Oscar Loew that Owens Lake contains 22,000,000 tons of sodium carbonate, 8,000,000 tons of potassium sulphate, over 40,000,000 tons of common salt, and 1,000,000 tons of borax. The borax is, however, in such a dilute solution that no means are known at present to utilize it.

The Reno Development Company has extensive works at Keeler, on the eastern shore of the lake, at the terminus of the railroad from Reno. The carbonate of soda is recovered by pumping the waters of the lake into clay vats, and evaporating by solar heat during the hot summer months. At the high temperatures of the summers the carbonate and bicarbonate of soda crystallize out, while the chloride and sulphate of soda remain in solution. In the winter these crystallize out with the carbonates, giving an impure product. The vat area of the company is something over one hundred acres, and the

SALINE VALLEY, INYO COUNTY.

SEARLE'S BORAX WORKS, SEARLE'S LAKE, SAN BERNARDINO COUNTY.

final result of a summer's work is a cake of soda from two to four inches thick over the surface of the vats.

This product is a compound of carbonate and bicarbonate of sodium with its water of crystallization. It is shipped in its natural form to the borax works, and used to produce commercial borax from colemanite (borate of lime), or is calcined to soda ash and sold to glass works and washing-soda factories. Some has been shipped to Japan, where it met with a most favorable reception, as it is equal to the best English soda ash. The reports of shipments since 1893 are as follows:

	Tons.	Value.
1894	1,530	$20,000
1895	1,900	47,500
1896	3,000	65,000
1897	5,000	110,000
1898	7,000	154,000
1899	10,000	250,000
1900	1,000	50,000

MONO COUNTY.

120 **Mono Lake.**—Is situated about 10 miles south of Bodie, on the line of the Bodie & Benton Railroad, at an elevation of 6730 feet; the highest level above the ocean of all the saline lakes of the Great Basin. In many respects it is the most interesting to study of all the lakes of California.

Its location and appearance are unique and attractive, for it rests upon the desert plain like a sheet of burnished metal, with the desolation and solitude of a Sahara on the east, and the rugged grandeur of the Pyrenees on the west. The lake is now roughly circular in outline, its north and south axis measuring 10 miles, and its east and west axis 14 miles; it is a veritable "dead sea" without an outlet.

Its area, including the islands, is 87 square miles. Its deepest point, at the south end of Paoho Island, is 152 feet, the average depth being 62 feet. The shore phenomena exhibited about the borders of Mono and Aurora valleys, in common with other lakes, consist of terraces, with their accompanying sea-cliffs, gravel bars, deltas, etc., some of the ancient terraces being 672 feet above the present lake.

To adequately describe the geological history of this one lake would require a large volume, and it must suffice here to say that it is lacustral, glacial, and volcanic. While its general history is that of the other lakes of the Great Basin, its local phenomena are of unusual interest, and marked with exceptional clearness. The old terraces, showing the levels of its waters in each of the older geologic times, are clearly visible on every side. The carving and modeling of the mountain sides, by the huge ice plows of the days of the glaciers, give studies as fascinating as those of Mont Blanc. The streams that flow into the lake all flow over, or through, volcanic rocks; while the islands of the lake are themselves of volcanic origin, showing ancient craters and active hot springs.

121 **Hot Springs.**—There are numerous thermal springs around the lake, and a number that boil up from the bottom of the lake-bed. The submerged springs are especially noticeable near Black Point. There is a hot spring of special interest on the east side of Paoho Island; and there are also fumaroles on this island that give forth vapors that have a temperature of 150° F. The phenomena of hot springs and fumaroles indicate that the volcanic energy that extracted the lavas is not yet entirely dissipated. A warm spring on the northeast shore of the lake, that discharges about 10 gallons per minute, has been analyzed by T. M. Chatard, of the U. S. Geological Survey, with the following result:

Temperature between 80° and 90° F.

Silica	5.89
Alumina	0.09
Calcium	2.84
Magnesium	2.92
Potassium	3.05
Sodium	29.56
Sulphuric acid	15.13
Chlorine	10.98
Oxygen	1.57

This analysis shows that the main salines in the spring water are salt (sodium chloride) and sodium sulphate.

One of the minerals of interest, to science rather than to commerce, is the crystalline variety of tufa, known as thinolite, which, so far, has only been found in the basin of Lake Lahontan, and is abundant at Mono Lake.

The waters of Mono Lake are so dense and alkaline as to be as deadly to the thirsty traveler as is ocean water. One of the earlier analyses of the lake water was made by I. R. Morph:

	Per Cent.
Sodium chloride	5.8
Potassium chloride	1.5
Calcium chloride	2.6
Magnesium chloride	8.2
Calcium sulphate	.4
Boric acid	traces.

Another author gives the total weight of the solids per gallon as 2926 grains.

The analysis of Morph is incomplete and does not take into account the carbonates, the most valuable constituents of the water. The concentration of surface waters by evaporation produces, in general, brines of two characters; in one class, sodium chloride predominates over all the other salts; in the other class, alkaline carbonates are abundant. At this lake the alkaline carbonates are abundant because of the volcanic rocks of the lake basin, as shown by the complete analysis made by T. M. Chatard, which is as follows:

	Grams per Litre.
Silica	0.0700
Calcium bicarbonate	0.0810
Magnesium bicarbonate	0.3349
Potassium chloride	1.8342
Sodium chloride	18.5068
Sodium sulphate	9.8690
Sodium carbonate	18.6720
Sodium bicarbonate	3.9015
Sodium biborate	0.2000
Alumina	0.0030
	53.4724

a total of 53 grams of solids per litre, nearly 35 per cent of the total solids being the chloride of sodium, and over 40 per cent being the carbonate of sodium.

Experiments on the fractional crystallization of these waters by Professor Chatard gave the following results, showing the same general rule of deposition as at Owens Lake. The waters experimented upon were already evaporated to about one sixth of their original volume, and had a specific gravity of 1.210:

	1	2	3	4	5
Water	12.28	10.98	.69	4.18	11.31
Silica	.07	.17	.16	......	.13
Calcium carbonate	.05	.14	.05	.07	.02
Magnesium carbonate	.48	.46	.02	......	......
Potassium chloride	.69	.69	.47	.71	15.20
Sodium chloride	19.18	21.34	29.96	60.75	32.36
Sodium sulphate	2.73	14.18	49.13	16.22	6.65
Sodium carbonate	36.87	41.07	18.27	14.22	33.69
Sodium bicarbonate	27.37	10.99	10.03	3.88	.49
	99.72	100.02	99.78	100.03	99.85

Mono Lake has an area of 85.5 miles and an average depth of 61.5 feet. Its volume, then, is 5,365,816,000 cubic yards, or 0.984 cubic mile; which is equivalent to 1,083,755,500,000 gallons of 231 cubic inches each. One cubic foot equals 28.32 litres; each litre equals 1051.85 grams; a pound equals 4536 grams; and an acre foot equals 43.560 cubic feet. On this data, and from another analysis which closely agrees with that of Mr. Chatard, another authority of the U. S. Geological Survey makes the following calculation:

	Grams per Litre.	Tons in the Lake.
Silica	0.28	1,323,200
Calcium carbonate	0.68	3,213,400
Magnesium carbonate	0.36	1,701,200
Potassium chloride	2.23	10,538,000
Sodium chloride	18.22	86,099,600
Sodium sulphate	10.07	47,586,400
Sodium borate	0.20	945,100
Sodium carbonate	19.49	92,101,100
Unaccounted for	0.32	1,512,200
Total	51.85	245,020,200

The total weight of the lake is 4,725,557,000 tons of 2000 pounds each.

Such figures, by acknowledged authorities, of the saline reserves of a single lake that has not yet completely evaporated, enable one to see that the saline reserves in the host of completely evaporated or playa lakes of the deserts of this State are beyond computation, and are practically inexhaustible, even when transportation facilities have been developed to the highest degree of perfection.

122 **Long Valley.**—Lies southeast of Mono Lake. The country is highly volcanic, and the rocks in many places much decomposed and coated with efflorescences and incrustations.

There are many warm springs the waters of which flow into lakes. The numerous soda lakes are connected together during the wet season, and drain into the head waters of Owens River. The shores show in most places a salt crust around the margins, but are difficult of access on account of the extensive morasses by which they are completely surrounded; morasses that are flooded with water in the winter. With facilities for transportation, Long Valley could be made to yield a considerable amount of soda annually.

MINERALOGY.

123 **Dawsonite.**—Carbonate of aluminum and sodium. A soft, white, earthy incrustation in volcanic dike, Amargosa Cañon, Inyo County.

124 **Thermonatrite.**—Hydrous sodium carbonate. Carbon dioxide, 35.5; soda, 50.0; water, 14.5. Color, white, grayish yellow. Hardness, 1. Gravity, 1.5. Taste, alkaline. Common as an efflorescence in Death Valley; and at the playa lakes of the deserts, and in many of the lakes and springs of the State.

125 **Natron.**—Soda. Soda carbonate. Carbon dioxide, 15.4; soda, 21.7; water, 62.9. Common in the springs of the State; mixed with trona or thermonatrite in the playa lakes and borax lakes of the State.

126 **Gay-Lussite.**—Hydrous carbonate of calcium and sodium. Calcium carbonate, 33.8; sodium carbonate, 35.8; water, 30.4. Color, white to yellowish white. Hardness, 2 to 3. Gravity, 1.93. Owl Springs niter beds, San Bernardino County.

127 **Trona.**—Hydrous carbonate of soda. Carbon dioxide, 38.9; soda, 41.2; water, 19.9. Color, gray or yellowish white. Hardness, 2.5 to 3. Gravity, 1.93. Taste, alkaline. Not altered by exposure to dry atmosphere. Soluble in water and effervesces with acid.

In fine crystals at Searles Borax Lake, San Bernardino County, mixed with hanksite, glauberite, etc. Formed by the spontaneous evaporation of the saline waters of Owens Lake, Inyo County. Extensive deposits, or beds, in some of the playa lakes in the deserts of Kern, Inyo, San Bernardino, and Riverside counties.

128 **Hydromagnesite.**—Basic magnesium carbonate. Carbon dioxide, 36.3; magnesia, 43.9; water, 19.8. Color, white. Hardness, 3.5. Gravity, 2.14. Occurs as chalky or mealy crusts in some spots along the Amargosa River in Inyo County.

129 **Bismutite.**—A basic carbonate of bismuth. White to greenish yellow. Hardness, 4 to 4.5. Gravity, 6.86. Found in gold placers on Big Pine Creek, Inyo County.

130 **Magnesite.**—Magnesium carbonate. Carbon dioxide, 52.4; magnesia, 47.6. White, gray white to brown.

Napa County: Cats Hill.

Santa Clara County: Coyote Creek, 2 miles from Madrone, in a large deposit.

Placer County: Gold Run and Damascus in considerable quantities.

Monterey County: Arroyo Seco; vein 2 feet wide.

Tulare County: Between Four Creeks and Moore Creek, near Visalia, in solid beds of massive carbonate of magnesia 106 feet thick, interstratified with talcose slates and serpentine.

Alameda County: Diablo range, 30 miles south of Mount Diablo; beds similar to the Tulare.

SALTON SEA, RIVERSIDE COUNTY.

HOUSE OF ROCK SALT, DANBY LAKE, SAN BERNARDINO COUNTY.

PART IV.

CHLORIDES.

131 SALT.

Sodium chloride ($NaCl$), or "common salt," contains 39.39 per cent sodium and 60.61 per cent chlorine.

It crystallizes in cubes when the crystallization occurs on the surface of the vats, the crystals uniting in the well-known "hopper forms."

The crystals formed on the bottom of the vats are generally incompletely developed.

California stands sixth in the list of salt-producers among the States, the order being as follows: 1, Michigan; 2, New York; 3, Ohio; 4, West Virginia; 5, Louisiana; 6, California; followed by Utah, Nevada, Illinois, Indiana, Virginia, Kentucky, etc.

In this State the bright sunshine and dry atmosphere give the manufacturers a decided advantage over those of the East. Here one does not find the open pans, vacuum pans, kettles, and grainers, as solar heat alone is used, except to a very limited degree. In one county only is artificial heat used for refining salt for table and dairy use.

The standard of measure in California is the short ton; and in the East it is the "barrel" of 280 pounds, or 5 bushels of 56 pounds each, so that the ton is equivalent to $7\frac{1}{7}$ barrels.

The main supply of salt is from the ocean water of San Francisco Bay, the process used being given under the title of "Alameda County."

Ocean waters carry, on the average, 35.19 parts per thousand of solid matter in solution, composed as follows:

Chloride of sodium	77.758
Chloride of magnesium	10.878
Sulphate of magnesium	4.737
Sulphate of calcium	3.600
Sulphate of potassium	2.465
Bromide of magnesium	0.221
Carbonate of calcium	0.341
	100.000

According to locality, the shore waters may vary considerably in character, carrying more or less of the chloride of potassium, calcium, barium, or ammonium; traces of the bromides of calcium and sodium, iodides of sodium and magnesium; sulphate of aluminum; carbonates of sodium, magnesium, iron, and manganese; or even silicates, phosphates, and organic matter.

The origin of the beds and veins of salt will be found under the general view of the Great Basin, as it has been collecting for ages in the desert lakes that had no outlet. (See titles "Chemical" and "Order of Deposits.") Rock salt is found in beds or veins below the bed of the playa lakes and in the alternating strata of the terrace deposits. The effect of the rapid evaporation on the desert in forming new crusts is noted under the titles "Amargosa River Beds," "Searles Lake," and "Salton Sea." The chemical impurities due to drifting sands are noted under the title "Æolian Sands."

The history of the gathering of salt dates back to 1848 and 1849, when the natives gathered solar salt from the natural reservoirs along the San Francisco Bay. In 1867 salt works were erected at San Rafael, in Marin County, and some salt was made. In 1882 there were twenty-five establishments in the State with $365,000 capital, employing an average of 184 hands, and producing 884,443 bushels of salt, worth then over $120,000. The progress from that time has been steady.

While consolidation has mainly confined the production of salt to the counties of Alameda and Riverside, there are enormous quantities existing elsewhere which only await the coming of favorable conditions in transportation to enter the field of commerce. No State in the Union has larger reserves of salt to draw from in the future than has California.

MINERALOGY.

The list of mineral chlorides is a short one, and only Halite, or common salt, is found in commercial quantities in the State.

132 **Halite.**—Common salt; rock salt. Chlorine, 39.4; sodium, 60.6 per cent. Common in many of the counties of the State.

133 **Sylvite.**—Chloride of potassium. Chlorine, 47.6; potassium, 52.4 per cent. Transparent when pure. Tastes like common salt. Gives violet flame, while the sodium compound gives yellow flame, under a blowpipe. Found in traces only in some of the springs of Inyo County.

134 **Sal-ammoniac.**—Chloride of ammonia. Chlorine, 66.3; ammonium, 33.7 per cent. Occurs as an efflorescence at some of the fissure, or volcanic, springs in Death Valley.

135 **Chloromagnesite.**—Magnesium chloride. Saratoga Springs, Death Valley.

Production of Salt in California, in Tons.

Year.	Alameda.		Riverside.		San Bernardino.		San Diego.		Colusa.		Unapportioned.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1887	......	......	......	......	......	......	......	......	......	......	......	......	28,000	$112,000
1888	......	......	......	......	......	......	......	......	......	......	......	......	30,800	92,400
1889	......	......	......	......	......	......	......	......	......	......	......	......	21,000	63,000
1890	......	......	......	......	......	......	......	......	......	......	......	......	8,729	57,083
1891	......	......	......	......	......	......	......	......	......	......	......	......	20,094	90,303
1892	......	......	......	......	......	......	......	......	......	......	......	......	23,570	104,788
1893	......	......	......	......	......	......	......	......	......	......	......	......	50,500	213,000
1894	44,450	$125,125	1,981	$3,962	1,000	$3,000	700	$5,000	....	....	1,000	$3,000	49,131	140,087
1895	43,810	114,575	4,000	8,000	3,481	20,101	700	5,000	40	$400	1,000	2,500	53,031	150,576
1896	55,026	122,810	4,317	8,634	3,000	15,000	600	4,800	....	....	1 000	2,000	64,743	153,244
1897	64,353	139,830	4,840	9,680	......	......	650	5,850	8	160	1,000	2,000	67,851	157,520
1898	87,800	155,812	5,000	10,000	......	......	600	5,000	21	43	......	......	93,421	170,855
1899	78,434	137,088	3,600	7,200	......	......	600	5,000	20	300	......	......	82,654	149,588
1900	64,718	158,674	4,000	8,000	......	......	600	4,000	20	80	20,000	34,000	89,338	204,754
1901	114,450	324,136	4,000	12,000	......	......	1,060	9,620	18	270	40	400	126,218	366,376
													809,080	$2,225,576

137 Salt Imported into the United States.

Year	In Barrels, Bags, etc.		In Bulk.		Total Value.
	Tons.	Value.	Tons.	Value.	
1867.......	127,235	$696,570	114,152	$336,302	$1,032,872
1868.......	154,223	915,546	109,987	365,456	1,281,004
1869.......	148,691	895,272	128,382	351,168	1,246,440
1870.......	144,239	797,194	174,888	507,874	1,305,068
1871	141,996	800,454	137,365	355,318	1,155,772
1872	129,116	788,893	128,818	312,596	1,101,462
1873.......	119,747	1,254,818	194,006	525,585	1,780,403
1874	179,186	1,452,161	213,647	649,838	2,001,999
1875	159,336	1,200,541	200,635	549,111	1,749,652
1876.......	165,633	1,153,480	189,739	462,106	1,615,586
1877.......	179,502	1,059,941	222,022	532,831	1,592,772
1878.......	176,054	1,062,995	207,406	483,909	1,546,904
1879.......	187,643	1,150,018	217,380	532,706	1,682,724
1880	200,485	1,180,082	224,871	548,425	1,728,507
1881..	206,221	1,242,543	264,680	658,068	1,900,611
1882.......	164,984	1,086,932	199,550	474,230	1,561,162
1883.......	156,455	1,035,946	206,469	451,001	1,486,947
1884.......	170,379	1,093,628	220,806	433,827	1,527,455
1885......	175,638	1,030,029	206,161	386,855	1,416,887
1886.......	159,616	966,993	183,310	371,000	1,337,993
1887.......	137,887	850,069	176,608	328,201	1,178,270
1888.......	169,460	620,425	136,325	246,022	866,447
1889.......	90,453	627,134	117,249	249,232	876,366
1890.......	86,305	575,260	121,878	252,848	828,108
1891.......	75,016	492,144	110,154	224,569	7,161,713
1892.......	75,399	488,108	100,683	196,371	684,479
1893.	49,018	358,575	73,472	63,404	421,979
1894.......	39,396	206,229	50,762	86,718	292,947
1895	300	1,723	937	1,874	3.597

	Metric Tons.	Value.
1896	239,334	$696,197
1897	209,479	611,166
1898	169,786	587,348
1899	175,260	587,103
1900	188,595	633,192

SALT WORKS, ALAMEDA COUNTY.

SALT WORKS, ALAMEDA COUNTY.

138 **Salt Exported from the United States.**

1849	$62,972	1867	$304,030	1885	$26,488
1850	75,103	1868	289,936	1886	29,586
1851	61,424	1869	190,076	1887	27,177
1852	89,316	1870	119,582	1888	32,986
1853	119,729	1871	47,115	1889	31,405
1854	159,026	1872	19,978	1890	30,079
1855	156,879	1873	43,777	1891	23,771
1856	311,495	1874	15,701	1892	28,399
1857	190,699	1875	16,273	1893	38,375
1858	162,650	1876	18,378	1894	46,780
1859	212,710	1877	20,133	1895	30,939
1860	129,717	1878	24,968	1896	14,947
1861	144,046	1879	13,612	1897	10,189
1862	228,109	1880	6,613	1898	4,751
1863	277,838	1881	14,752	1899	9,858
1864	296,088	1882	18,265	1900	3,907
1865	358,109	1883	17,321	1901	86,414
1866	300,980	1884	26,007		

139

ALAMEDA COUNTY.

The recovery of salt from the waters of San Francisco Bay, by solar evaporation, is one of the leading industries of the county. Most of the works are in the vicinity of Alvarado, Newark, and Mount Eden, on the east side of the bay, at the south end. As early as 1848 and 1849, the natives gathered solar salt from the natural reservoirs that were left along the shores of the bay, when the tide went out. This salt was, however, of inferior quality.

Originally the salt ponds were simply natural lagoons in the marshy coast of the bay. To-day there is an elaborate system of dikes with gates, by which large ponds are filled at high tide, the filling generally taking place once a month. Some of the huge ponds and vats have board floors. As evaporation progresses, the water is drawn from one vat to another until it is sufficiently concentrated for the salt to crystallize out.

In 1862 John Quigley began work on a large scale at Alvarado, or Union City, and by 1868 salt works extended from San Leandro Creek to Centerville, a distance of 15 miles, some 17,000 tons being produced annually.

Some of the works in this county that have been prominent in the production of salt are as follows:

American Salt Works.—2 miles west of Mount Eden. 12,000 tons capacity.

SALT WORKS, REDONDO, LOS ANGELES COUNTY.

SALT WORKS, ALAMEDA COUNTY.

ALVARADO SALT WORKS.—1½ miles west of Alvarado. 3,000 tons capacity.

BAUMBERGER'S.—2½ miles southwest of Mount Eden. 350 tons capacity.

CARMEN ISLAND SALT WORKS.—4 miles east of Alvarado.

CRYSTAL SALT WORKS.—1½ miles south of Alvarado; also at Newark.

COX'S.—2 miles west of Mount Eden. Small.

CHRISTENSEN, P. J.—Mount Eden.

COMET SALT COMPANY.—Mount Eden.

DROSTE, H.—Mount Eden.

HAYWARDS LUMBER COMPANY.—Haywards.

JOHNSON, A. L.—Mount Eden.

MATHIESEN, H.—San Lorenzo.

MATHIESEN, E. P.—Mount Eden.

MADSEN SALT WORKS.—Mount Eden.

MOUNT EDEN SALT WORKS.—Mount Eden.

OAKLAND SALT WORKS.—Alvarado.

OLIVER & CO. SALT WORKS.—Mount Eden.

OCCIDENTAL SALT WORKS.—Alvarado.

OLSEN, E.—Mount Eden.

NIELSON, M.—Mount Eden.

PUTNAM, W.—Alvarado.

PESTDORF, E. C.—Mount Eden.

PESTDORF, D.—Mount Eden.

PETERMAN, H.—Mount Eden.

PETERMAN, M.—Mount Eden.

PARADISE SALT WORKS.—Mount Eden.

ROCKY POINT SALT WORKS.—Mount Eden.

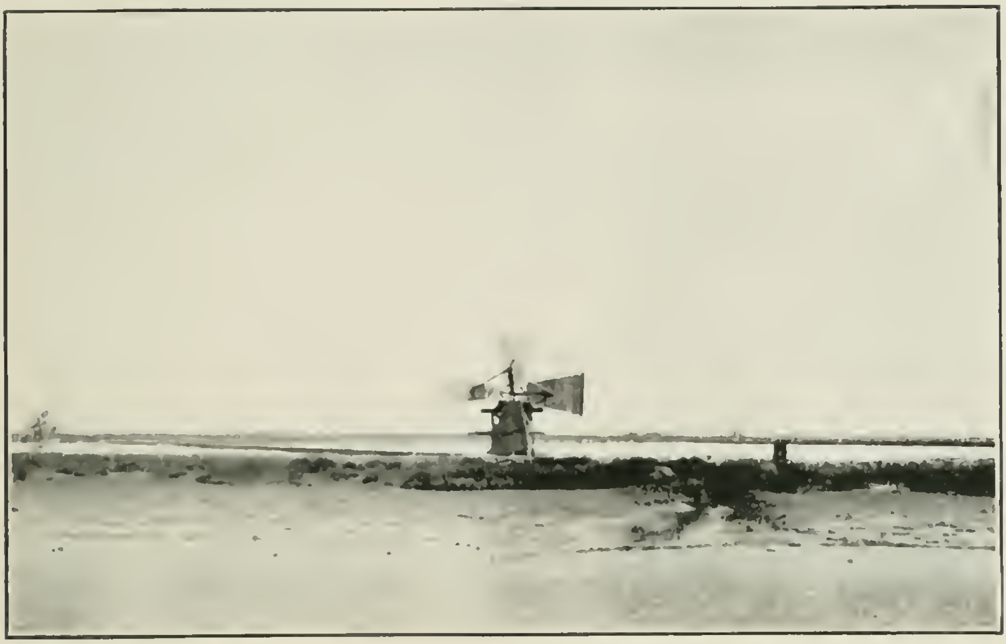
TUCKSON, J. P.—Mount Eden.

UNION CITY.—2 miles west of Alvarado.

UNION PACIFIC SALT WORKS.—3 miles west of Alvarado. 15,000 tons capacity.

WISBY.—2 miles southwest of Mount Eden. 3,000 tons capacity.

In 1900, the companies located on the tide lands around San Francisco Bay entered into a combination to secure better market conditions. Since the contract system was given up, the industry has been demoralized by overproduction and low prices. An independent company was organized near Alvarado, with a view of beginning production in 1901.



WINDMILLS SALT WORKS, ALAMEDA COUNTY.

ARCHIMEDES SCREW WINDMILL—ALAMEDA SALT WORKS. USED FOR PUMPING BRINE FROM THE TANKS

The accompanying photographs give a general view of the vats and principal works of the district. One of the unique features of this field is the use of windmills fastened to an Archimedes screw for raising the waters from one vat to another. As the cost of the entire affair is only about $50, they have proved very economical for these low lifts. The establishment, in the fall of 1901, of chemical works near Mount Eden and near Alviso, promises to give new interest to these fields.

An analysis of San Francisco Bay salt, made by F. Gutzkow, June, 1880, shows that the salt is remarkably pure, being 99.4 per cent pure sodium chloride.

The production in Alameda County since 1893 has been as follows:

	Tons.	Value.
1894	44,450	$125,125
1895	43,810	114,575
1896	55,026	122,810
1897	64,353	139,830
1898	87,800	155,812
1899	78,434	137,088
1900	64,718	158,674
1901	114,450	324,136

140 COLUSA COUNTY.

In 1890, the Antelope Crystal Salt Company began the manufacture of salt at the brine springs on the Peterson ranch, near Sites; but for some time only a few tons were made for local use. Salt springs are found in the ravines in the foothills along Antelope Valley; but the principal source of the salt is a small lake, of about 25 acres, that is located on the axis of an anticlinal, borings through the bed of blue clay giving a strong brine and inflammable gas. The brine contains 1500 grains of salt per U. S. gallon, and 2 grains of iodine.

A number of the mineral springs of the county carry considerable salt in their waters.

The production has been as follows:

	Tons.	Value
1895	40	$400
1896	none.	......
1897	8	160
1898	21	439
1899	20	300
1900	20	80
1901	18	270

SALT PILES, ALAMEDA COUNTY.

UNION PACIFIC SALT WORKS, ALAMEDA COUNTY.

141 INYO COUNTY.

Salt is abundant in nearly every valley, and along nearly all the streams of this county, which lies wholly within the boundaries of the Great Basin, and which includes within its boundaries a large portion of Lake Aubury.

Large quantities of salt are made at Owens Lake, and in the Saline and Salt Wells valleys, but records are not accessible. A large share of the "unapportioned" salt given in the published statistics comes from this county, and it is probable that it produces from 5000 to 10,000 tons a year.

142 **Bennett's Wells.**—The bottom of Death Valley opposite and north of these wells is one huge salt marsh, covering several townships. Some salt was produced here several years ago, when the Eagle Borax Company was at work; but nothing has been done since.

From the wells to the mouth of Furnace Creek, the valley is one long salt marsh, too soft and wet for one to cross it on foot. In some places the deep ooze has been crusted over, but this crust is very thin and treacherous, as a rule, and no bottom can be found to the slime below. In one place, the crust of salt and sand has been found thick enough to hold up wagons, and here the Borax Company made its road for crossing the bottom of Death Valley. Where the road crosses, the ragged, twisted, and jagged salt crust resembles ice crushed up along a shore.

This unique road, eight miles long, was made with sledge-hammers, the crust being beaten smooth.

143 **Confidenee Beds.**—The old Confidence gold mine, situated just east of the Narrows, where the Inyo County line crosses Death Valley, has given a name to the district. At the old mill site, in the bottom of Death Valley, a well was sunk some 59 feet deep, passing through alternating strata of sandstones and salines. The water was so strong a brine that it could not be used for mining purposes.

The whole valley between the mine and the niter beds to the west is saline in its character; and wherever any water comes to the surface it is saturated with salt. The deposits here cover over a township.

144 **Furnace Creek.**—(See "Borax.") The works of the Greenland Salt and Borax Company were located a couple of miles

CRYSTALLIZING VATS—SALT WORKS, ALAMEDA COUNTY.

GATHERING SALT FROM THE VATS, ALAMEDA COUNTY.

north of the mouth of Furnace Creek. Its road lay along the east side of Death Valley for several miles, and then crossed over to the springs. As the bottom of Death Valley is really one vast salt marsh, and in most places so soft and slimy that no one can cross it on foot, it was a serious problem how to get a road across. Finally a place was found where the salt and sand formed a crust strong enough to hold up a team, and this was leveled off for the distance of the eight miles necessary to cross the valley.

This road, probably the only one of its kind in the world, shows better than anything else the quantity of salt in the valley.

North of Furnace Creek the valley is white with salt that covers over two townships. Much of this salt is fine and pure, being of much better quality than along the edges, where it is mixed with borax, etc.

145 **Owens Lake.**—While the waters of Owens Lake contain large quantities of salt, associated with carbonate of soda, and salt has been made there, no statistics of the amounts remain. (See "Carbonates" for description of the lake.)

146 **Saline Valley.**—Extensive deposits of pure rock salt were discovered in this valley in 1864, and the mineral has been used locally, but not shipped. Salt springs, borax beds, and salt beds are numerous and extensive; but lack of transportation facilities has prohibited nearly all development.

147 **Salt Wells Valley.**—The Salt Wells Borax Company in former years made some salt, as a by-product, at its borax works. The Inyo County extension of Searles Lake Valley is richer in salt than the San Bernardino portion, while the borax is almost wholly confined to the southern end of the valley. (See "Searles Lake," under "Borates.")

148 **Tecopah.**—Wells dug in the playa deposits at Tecopah show strata similar in character to those of the well at the Confidence mine. This playa lake at the head of Willow Creek is but a branch of the Resting Springs lake. The alternating strata are rich in salt, as well as in borax and soda compounds. (See "Niter.")

149 **Upper Canon Beds.**—The strata of the niter beds in the cañon of the Amargosa contain numerous layers rich in salt,

A SALT BED IN THE DESERT, INYO COUNTY, AMARGOSA VALLEY.

INDIO, RIVERSIDE COUNTY.

and some rock salt. It is probable that development of the field, especially by borings, will show that the heavy veins of rock salt found lower down on the valley also exist here, near the lower gypsum beds. (See "Niter.")

150 **Amargosa River.**—The Amargosa River might be called an artery of salt running through the desert, so saline are its waters along its entire course. Where it widens out into the large playa lake at Resting Springs, it leaves large salt fields, as well as those of borax and niter. Wherever its waters rise to the surface, they form brine springs. The desert for many miles on either side of the course of the river is dotted with spots and patches of salt. (See "Lake Aubury," under "Borates.)

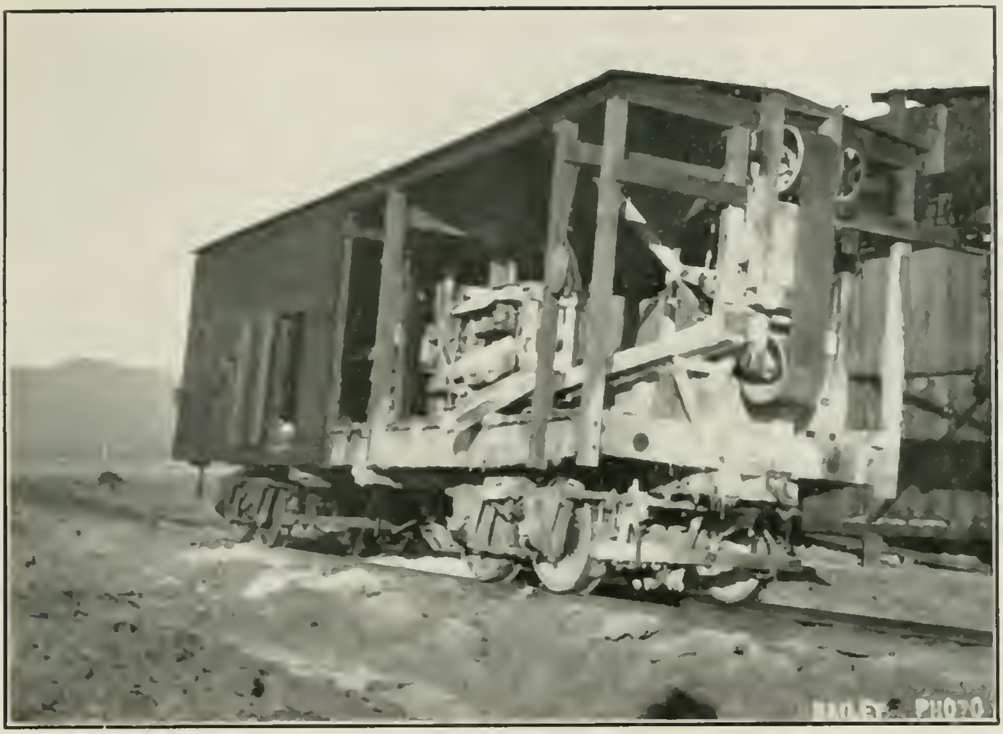
151 **Springs.**—To give a list of the springs carrying noticeable quantities of salt, in this county, would be to name nearly every spring in the desert portions. A large percentage of them are strong brines, like the Castalian Spring, near Owens Lake, which carries 1840 grains of salt per gallon. (See "Desert Springs.")

KERN COUNTY.

152 **Cameron Lake.**—At the east end of Tehachapi Pass is a salt lake about one mile square, where the saline stratum is from 5 to 6 feet deep. At times the lake-bed is covered with a shallow sheet of water that is a saturated solution of salt, muddy from the fine clay held in suspension. During the summer season the water nearly all disappears, leaving a salt crust from 3 to 4 inches thick. From 200 to 300 tons a year are gathered by the simple process of raking. The salt is of good quality, running from 92 to 98 per cent pure. No statistics of the yield of this lake seem to have been kept in the past.

A number of salt wells give the name of Salt Wells Valley to a considerable area of land in the northeast corner of the county.

Casteca Lake, at the head of the Cañada de las Uvas, is a shallow playa lake that in dry seasons is covered by a thick crust of salt, left by the evaporating waters. The country from the Kern River to the Cañada de las Uvas is in fact an alkaline desert, where the soil is heavily impregnated with salt, and at one point, about fourteen miles from the cañon of



CAR FOR LOADING SALT SALTON, RIVERSIDE COUNTY.

SALT WORKS, REDONDO, LOS ANGELES COUNTY.

the Cañada River, works were erected some years ago, and some salt made by lixiviation and crystallization. Salt is found in large quantities in the playa lakes at Buckhorn, Indian, and Mesquite springs. (See "Borates.")

153 LOS ANGELES COUNTY.

Salt works were erected some years ago at Redondo, on a small lagoon about half a mile north of town. The waters of the lagoon contain a strong brine, but the work of making salt was interrupted first by one misfortune, and then another. The works were equipped with considerable machinery, that was taken down and removed in the fall of 1901; and the present operations are confined to vat work and solar evaporation on a small scale.

At the City of Los Angeles, the New Liverpool Salt Company has a branch of its Salton works, for preparing the finer grades of salt.

154 MONO COUNTY.

Mono Lake is rich in salt, as well as in soda carbonate. Owing to its distance from commercial centers, but little salt has been made here, except for local use. The lake is described under the head of "Carbonates."

155 RIVERSIDE COUNTY.

"Salton Sea" is a name familiar to every one in the West. By a few, it has been misnamed "Death Valley," owing to the confusion arising from its position in the Colorado Desert, from its extreme heat, and from the fact that it is below sea-level. Death Valley proper lies mainly in Inyo County, extending southward about 20 miles, into San Bernardino County, in the Mojave Desert.

Salton Sea means the depression lying to the west and south of the Southern Pacific Railroad. It is about 27 miles long, and from 3½ to 9 miles wide, embracing an area of about 156 square miles, and is 280 feet below sea-level at its lowest point.

It receives the drainage of some 8000 to 9000 square miles of desert country. Especially high floods on the Colorado River have reached Salton by New River and Salton or East River. (See "Lake Le Conte.")

The town of Salton is situated on the Southern Pacific Rail-

PLOW AT WORK, SALTON.

LOADING CARS, SALTON.

road, 70 miles west of Yuma, or 180 miles east of Los Angeles. The elevation is 265 feet *below* sea-level, the lowest elevation of any town in the Union.

The New Liverpool Salt Company began work on the salt beds of Salton Sea in 1884, producing some 1500 tons. Since then, progress has been rapid. As solar heat alone is necessary in the desert, the mill plant consists only of machinery for grinding and bagging the salt for shipment.

Salton Sea has been written upon repeatedly in magazines and newspapers, so that it is a familiar name to all. As one approaches the lake, "it looks like an immense crystal lake, and the houses and sheds of the salt works appear to be suspended in the air, as in mirage. As far as the eye can see the white and dazzling field of salt extends toward the horizon."

The sight at the salt works is an interesting one, for thousands of tons are piled up like huge snow drifts, and a large force of men is busy in preparing and packing, ready for market, salt of all grades and kinds. The workmen are Indians, belonging to the Coahuilla tribe, and are large, well-developed men, who are not affected by the dazzling sunlight, and who are able to work ten hours a day with the thermometer registering 150° in the sun. The Indians operate cable plows, that cut salt furrows 8 feet wide and 6 inches deep, each plow harvesting over 700 tons of pure salt per day. A portable railroad conveys the salt to the works.

The lake is constantly being supplied by numerous springs in the adjacent foothills, which flow into the basin and quickly evaporate, leaving deposits of very pure salt that vary from 10 to 20 inches in thickness.

Published analyses of the natural crusts from Salton show that the salt is naturally remarkably pure, being free from any noticeable percentage of the earthy chlorides and sulphates:

Sodium chloride	94.68	97.76
Sodium sulphate	.68	.70
Calcium sulphate	.77	.38
Magnesium sulphate	3.12	......
Water	.75	.96
Insoluble	....	.20
	100.00	100.00

This salt remains dry in an ordinary atmosphere, and is free from organic matter.

The terraces of Lake Le Conte are noticeable everywhere

MILL AND PILES OF SALT, LOOKING SOUTH—SALTON.

THE FLOODING OF SALTON SEA.

along the foothills, showing the different levels at which the lake stood in recent geological times.

Borings made at Salton give the following strata:

(1.) Below the salt crust was 6 inches of mud resting on:

(2.) 7 inches of a crust composed of chlorides of sodium and magnesium.

(3.) 22 feet of black ooze containing 50 per cent of water, and carrying both the chlorides and carbonates of sodium and magnesium.

(4.) The rest of the 300 feet of the boring was in hard clay, with a few streaks of cement.

156 ## SAN BERNARDINO COUNTY.

San Bernardino County produced from 1000 to 3000 tons of salt for several years, mainly for use at silver mills; but that demand having ceased, very little has been made recently. The supplies of salt are inexhaustible, and widely distributed over the desert portion of the county.

157 **Amargosa River Beds.**—The Amargosa River emerges from its cañon a short distance below the Lower Cañon niter beds, enters the southern arm of Death Valley, and thence runs north in a long curve, entering Inyo County again some 25 miles west of the cañon.

Wherever the river rises to the surface in this part of the valley, the water is a strong brine; and the edges of the stream are white with the saline efflorescence, or heavy with a crust of salt or borax, according to locality. (See "Borax," "Niter," etc.)

158 **Avawatz Mountains Rock Salt.**—In the strata of sedimentary formations underlying the Saratoga niter beds, that are on the north flank of the Avawatz range, south of the Saratoga borax flats, there are a number of strata of sand that are heavily impregnated with salt, which is, however, too impure to be of value, except in the remote future.

At the east end of the field, in a cañon near the Daggett road, a large vein of rock salt outcrops. This vein, or bed, of solid rock salt (over 95 per cent pure chloride of sodium) is from 12 to 16 feet thick. It is tinged to brown and pink from iron. The vein outcrops along the side of the ravine for a distance of over 1500 feet, and is both overlaid and underlaid by a mixture of sand and salt for a thickness of 25 feet above

NEW LIVERPOOL SALT WORKS, SALTON, RIVERSIDE COUNTY.

ROCK SALT OUTCROP, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

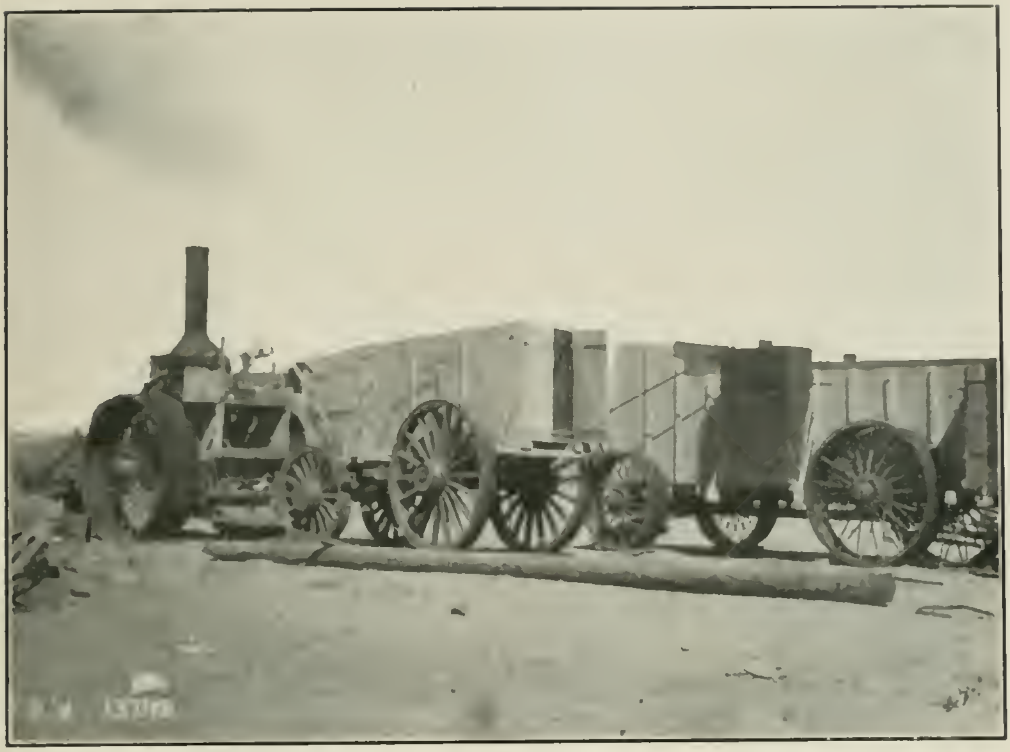
and below. Above the salt are strata of gypsum and sandstone, and beds of sulphate of soda, carbonate of soda, nitrate of soda, etc. This bed is on the west side of the road from Daggett to Death Valley. On the east side of the road, and about half a mile from it, are alternating strata of sandstone, gypsum, rock salt, salt mixed with sand, sulphate of soda, etc.; but no vein of rock salt has been found as thick and pure as the one on the south side of the road. These beds were discovered, and the salt used, many years ago when the Ibex and Confidence mines were in operation; the salt was used to a limited extent in their mills. (See "Niter.")

159 **Bitter Springs.**—These salt springs are located on the south side of Soda Lake Mountains, in Township 13 North, Range 7 East, S. B. M.

160 **Daggett.**—A few miles from Daggett the desert is underlaid by extensive beds of salt, mixed with sand, that was mined locally to some extent by the silver miners some years ago. Salt is common at the borax beds of the Calico district, already described.

161 **Danby.**—The Surprise salt mines are located about 25 miles southeast of Danby, a station on the Santa Fé Railroad. They are located in the bottom of a dry valley, about 6 miles from the south end of Old Woman's Mountain. The rock salt lies in two strata, each from 2 inches to 8 feet in thickness, separated from each other by a thick seam of clay, and covered by a layer of sand and dust that is from a few inches to 2 feet in thickness. The salt bed has been developed over a tract of some 40 acres, and the claims of the locators cover over 800 acres. For some time this deposit was worked by the Crystal Salt Company, who hauled the salt to Danby in traction wagons. The larger portion of the product was sold to the silver mills for use in chloridizing. Some of this salt has been shipped to San Francisco, and proved to be of superior quality.

In 1882, J. B. Cook is said to have dug a shaft 35 feet deep in solid rock salt, before water was reached. A 65-foot shaft, now caved in, is said to have shown 22 feet of solid crystal salt. An analysis of the clear rock salt gave: Sodium chloride, 98 per cent; water, 1.3 per cent; and traces of silica, iron, aluminum, potassium, and calcium. A small spring of good water



DESERT WAGONS—LOCOMOBILE TRAINS USED AT DANBY SALT MINES ON MOJAVE DESERT, SAN BERNARDINO COUNTY.

A VEIN OF SOLID ROCK SALT, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

exists $3\frac{1}{2}$ miles from the lake, while a large spring is situated 13 miles distant.

162 **Lower Canon Beds.**—Large quantities of salt, associated with other salines, are found at the Lower Cañon niter beds, and some of the alternating strata of the beds are largely salt and sand.

163 **Mojave River.**—This river, traversing the desert throughout its course, is naturally saline, but not so much so as the Amargosa. Salt may be observed in patches, or as an efflorescence all along its course.

164 **Mojave Sink, or Soda Lake.**—The depression where the Mojave River disappears beneath the sands of the desert is known both as "Mojave Sink" and as "Soda Lake," appearing on some maps under one name, and on other maps by the other name. The waters of the lake during the wet season have been found to vary all the way from 282 parts of solids in 100,000 to a saturated solution. In the dry season the greater portion of the depression is covered by a heavy crust of salt, rich in carbonate of soda and sulphate of lime, the proportions being as follows:

Sodium chloride	60.5
Sodium sulphate	22.5
Calcium sulphate	7.5
Magnesium sulphate	3.0
Organic matter	6.5
	100.0

The crust also contains traces of silica, phosphoric acid, potassium, and lithia. The area of the basin is about 20 miles long by 4 miles wide, or 80 square miles. No attempt has ever been made to utilize these deposits.

165 **Owl Springs.**—Salt is found in many of the strata at the Owl Springs niter beds, as described elsewhere in this bulletin.

166 **Salt Springs.**—The Salt Springs are located on the South Fork of the Amargosa River, at the east edge of Death Valley. These springs have been known for years, as the old Salt Lake road ran by them. The springs boil out in large volume in the short cañon of the South Fork, but the waters quickly disappear beneath the sands of Death Valley. This cañon is

SALT VATS, NEAR OCEANSIDE, SAN DIEGO COUNTY.

SALT MARSH, SAN DIEGO COUNTY.

of interest, as the river here cuts through the narrow and low divide that separates the watersheds of the Amargosa and Mojave rivers; it marks the place where the evaporating waters of Death Valley once joined those of Mojave Lake, showing clearly one of the shore lines of the still older Lake Aubury. The waters of the springs are strongly saline, and the sandstones of the cañon carry a considerable percentage of salt. These springs are at the west edge of the large playa lake known as the Salt Springs niter beds, described elsewhere.

167 **Saratoga Borax Beds.**—The character of the bottom of Death Valley along the Amargosa River, and in the borax beds around Saratoga Springs, has already been described, and it is only necessary to mention here that the borax beds in the valley at this point carry from 8 to 20 per cent of salt. Stretching for miles below the borax flats, the bottom of the valley is white with salt crust, making the total quantity run to enormous amounts.

168 **Searles Lake.**—The basin known as Searles Borax Lake has large quantities of salt crust covering the flats for miles north of and around the borax flats. The borax beds themselves carry from 10 to 12 per cent of salt. The northern extension of this lake is known in Inyo County as Salt Wells Valley (which see). (See also "Searles Lake.")

169 **Soda Spring.**—This is a spring on the west edge of the Sink of the Mojave, in Township 12 North, Range 8 East, S. B. M. The waters are strongly saline and carry salt, sulphate of soda, and sulphate of magnesia.

170 **Valley Springs.**—These springs rise in the bottom of Death Valley, about half way between Saratoga Springs and the old Confidence mine, in Township 19 North, Range 5 East, S. B. M. (unsurveyed). The springs are probably nothing more than the Amargosa River coming to the surface, as there is evidently a rock reef extending across the valley half a mile below the springs. The volume of water that gushes forth also corroborates this view. The brine is very strong, the total solids being 4422.25 grains in a U. S. gallon of the water.

An analysis made by Thomas Price, of San Francisco, is as follows:

	Grains per Gallon.
Sodium chloride	1840.72
Sodium carbonate	1724.11
Sodium sulphate	651.02
Sodium sulphide	46.34
Potassium chloride	132.30
Silica	14.28
Organic matter	13.48

Traces of magnesia, lime, bromine, iron, boric acid, phosphoric acid.

The valley on each side of the springs is white with salt crust. The alternating strata of the Valley niter beds, which join these springs, carry strata of sand that is heavily impregnated with salt and sulphate of soda, too impure, however, to be of commercial value for years to come.

171 **Willard's Wells.**—These are brackish saline wells on the edge of a large playa lake, about 15 miles east of Johannesburg. The road from Johannesburg to Granite Wells skirts the north shore of the lake. Like most of the playas, the bed of the old lake is strong with salt, and the shore is marked by the white crusts.

Many other desert springs might be mentioned as saline in this desert, in fact most of those whose location is given under the title of "Playa Lakes." (See list of "Desert Springs.")

SAN DIEGO COUNTY.

172 **Coronado.**—Salt is being made at the south end of San Diego Bay, about 12 miles from Coronado. The works are owned by E. S. Babcock, the proprietor of the Coronado Hotel. Solar evaporation only is used, and the works are similar in character to those along the bay near San Francisco.

173 **Oceanside.**—The California Salt Company has started salt-making at its points in this county, utilizing as the source of brine old lagoons, or "sloughs," that empty into the ocean. These lagoons are dry most of the year, and the brine is secured from wells from 30 to 50 feet deep. At the company's Carlsbad plant, some $15,000 or more was spent in 1901 in installing a gasoline engine pumping plant, and the construction of about five acres of vats. These vats, constructed with plow and

scraper, are so arranged as to empty by gravity from the upper to the lower vats. A line of sluice-boxes distributes the brine from the pumps. As shown in the photographs, the wells are hitched tandem to the one pump. The company has had difficulty in preventing seepage from the vats, and has not as yet put any salt on the market. Its lease at Carlsbad covers 250 acres.

At La Costa, about seven miles south of Carlsbad, the company has about 25 acres of vats, but no other plant. It is the intention to put in a steam plant at this point. At Kelly's Slough the company also has 250 acres of land, unimproved at present.

174 **Sweetwater.**—As early as 1872 salt was made in the Sweetwater Creek near National City, and in the Otay, but nothing has been done there for a number of years.

175 IN GENERAL.

Salt is widely distributed through the State in small marshes, saline lakes, playa lakes, and especially in springs. The presence of salt in the numerous marshes and playa lakes has already been mentioned under the head of "Borates," with which the chloride of sodium is usually associated.

In the following memoranda, the quantity of salt is given from published analyses, and the amount present is given in grains per U. S. gallon of 231 cubic inches, except where especially stated to the contrary. The list is necessarily incomplete:

Calaveras County.—Salt springs on the Mokelumne River, 6 miles south of Silver Lake.

Contra Costa County.—Alhambra Mineral Springs; 399 grains.

Humboldt County.—Eureka Springs, at the edge of the bay; 1403 grains.

Lake County.—Allen Spring; 23 grains.
Borax Lake; 20 per cent of the solids is salt.
Lake Hachinhama; 8 per cent of the solids is salt.
Hot Borate Spring, Clear Lake; 86 grains.
Howard Spring; 101 grains.
Siegler Spring; 30 grains.

SALT WORKS NEAR OCEANSIDE, SAN DIEGO COUNTY. SIX 50-FOOT WELLS CONNECTED WITH ONE PUMP FOR DRAWING BRINE FROM THE LAGOON TO THE VATS.

PUMPING PLANT, OCEANSIDE SALT WORKS, SAN DIEGO COUNTY.

See "Register of Mines and Minerals of Lake County," by California State Mining Bureau, for analyses of these springs.

Los Angeles County.—Large salt springs are found 14 miles from the City of Los Angeles, but no analysis or description is available to date.

Mendocino County.—Salt is reported as present in several places in the county.

Napa County.—Ætna Springs; 28 grains.
Calistoga Springs; 23 grains.
White Sulphur Springs; 21 to 23 grains.

Placer County.—Salt springs are reported as existing near the Clipper Gap iron mine.

San Benito County.—Anderson's Springs; 54 grains.

Santa Clara County.—Pacific Congress Springs; 119 grains.
Alum Spring; 90 grains.
Azule Spring; 86 grains.
Blodgett Spring, near Gilroy; 10 grains.
New Almaden Spring.

San Luis Obispo County.—The name "Salinas" was given to the principal river of this county on account of the numerous saline springs that are found all along its banks and the banks of its tributaries.

Large salt springs and beds of rock salt are found at the head of the river. Black Lake, one half mile in diameter, located near the summit of the San José Mountains, is a lake of strong brine.

The Carrisa Plains is a dry lake five miles long, and from a half to two miles wide. It is covered with a salt crust from six inches to two feet thick. Salt from Black Lake and from Carrisa is used extensively locally, but not shipped.

Among the numerous springs in the county, the following have analyses published: At El Paso del Robles is the Mud Spring, with from 83 to 96 grains; the Sulphur Spring, 25 to 27 grains; Soda Spring, 25 grains; Garden Spring, 20 grains; Sand Spring, 92 grains; White Sulphur Spring, 31 grains; Iron Spring, 23 grains; and Congress Spring, 119 grains.

At San Luis Obispo is the Sycamore Spring, carrying 9 per cent.

DRYING SHEDS, SALT WORKS RIVERSIDE COUNTY.

POMPEY'S PILLAR, WILLOW CREEK, INYO COUNTY

Shasta County.—Salt was formerly made on Salt or Stinking Creek, 12 miles east of Redding, from a sandstone that is strongly impregnated with salines.

Siskiyou County.—A well near Yreka, 675 feet deep, flows a strong brine, which is used for local demands.

Solano County.—Tolenas Spring; 215 grains.

Sonoma County.—Santa Rosa Spring; 5 grains.
Skaggs; 5.9 grains.
White Sulphur Spring; 3.4 grains.

Tehama County.—The Tuscan Springs, described under "Borates."
Little Salt Creek.

PART V.

NITRATES.

176 ## IN GENERAL.

Common usage applies the term "niter" to the nitrate of sodium, which is also called "cubic saltpeter," and "Chili saltpeter," to distinguish it from the word "saltpeter," which in common usage means only the nitrate of potassium. Niter, or "nitrate of soda," when pure contains 63.5 per cent of nitrogen pentoxide and 36.5 per cent of sodium.

Native niter occurs in the Caucasus, in Daghestan, and in the trans-Caspian provinces of Russia, but is only exploited on a small scale for local wants. Nitrate deposits have been reported as discovered in South Africa, but the report has not been confirmed. Niter has been found in California recently in quantities that promise to rival those of the famous beds of Chili.

Niter has been made, in the manufactories, for years from various soda compounds; but the sole source of the native material has been the deserts of Chili, and is the main industry of that country. In 1892 the nitrate industry in Chili supplied more than half the exports, and paid to the national treasury of that country over $20,000,000 (silver) in export duties.

NITER IN CHILI.

177 ### LOCATION.

The niter districts of Chili lie from 15 to 35 miles inland from the Pacific coast. They start in the north at Hazpampa, 15 miles east of Pisagua; thence south to Lagunas 85 miles, parallel to the coast; then occurs a break of 60 miles; then niter again into the district of Tocopilla; thence to Taltal.

The line of nitrate deposits lies at the junction of the plain and coast line of hills, occurring in a narrow band following the east foot of the coast hills, at an elevation of from 3000 to

4000 feet. The best and most important deposits are found in the province of Tarapaca, on the west skirts of the plain of Tamarugal. This plain slopes westward from the Andes to the coast range, and has a width of from 30 to 40 miles, and a length of about 150 miles north and south, resembling in its general appearance the desert of the Mojave. Darwin, in "A Naturalist's Voyage," calls it "an ancient sea bed." The line of the nitrate deposits lies at the west edge of this ancient sea, but the line is often interrupted by deposits of other salines such as borax, soda, etc.; the same as in the beds of Inyo and San Bernardino counties, California. To quote the official descriptions: "The principal deposits of nitrate of soda are on the sides of some of the ravines, and in some of the hollows of the mountains in the district of Tarapaca." "The nitrate grounds vary in breadth, the average being about 500 yards." "There have been single yards that have produced nearly a ton of nitrate." "The analysis given runs from 6 to 64 per cent."

The crude nitrate of soda is called "caliche," and this caliche lies in beds from 6 inches to 12 feet thick, underneath a covering of conglomerate, or hard porphyritic cement, that is from 1 to 18 feet thick, and must be removed in order to reach the caliche. This first layer of hard rock is called "costra," and it also carries niter running from 5 to 20 per cent.

The standard of purity, or basis on which sales are made in Chili, is 95 per cent of nitrate of soda in the refined crystals. The impurities that have to be dealt with are mentioned elsewhere.

Sales of the nitrate are almost wholly effected in Valparaiso by a few large houses which export for themselves, or which act as agents for dealers in Europe and in the United States. It is claimed that the agents at Valparaiso try to keep the price of nitrates at Iquique, Tocopilla, Autofagasta, Aguas Blanco, Taltal, Junin, etc., as low as possible, so that prices there do not properly represent the value of the article in commerce.

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HISTORICAL.

The discovery of nitrates in South America dates from 1821, at which time these beds belonged to Peru. The first shipment to Europe took place in 1830, at which time the crude nitrate was worth 11 cents per kilogram (2.2 pounds), or about 5 cents per pound.

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY—MORRISON'S RANCH, ON WILLOW CREEK.

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY—MORRISON'S RANCH, ON WILLOW CREEK.

From 1830 to 1878, the period during which they were occupied by Peru, the beds yielded a total of 3,891,664 metric tons; one metric ton being 2204.6 pounds, or .9842 ton of 2240 pounds.

The methods of purifying the caliche remained very crude for a long time, the caiiche being boiled in small copper pans of native manufacture, as late as 1845; but at this date the exports did not amount to over 6000 tons a year. In 1855 the industry had grown so that thirty-seven different "officinas," or niter works, were in operation. Since 1869 more modern machinery has been slowly introduced, and the process of manufacture advanced. In 1884 the first combination among the workers was formed, but it lasted only three years. Under the effect of the combine, the price in September, 1884, was from $2.55 to $2.95 per 100 pounds, in silver, or from $1.60 to $1.85 in gold. In 1891 another combination was formed that lasted until 1893. In 1892 there were nineteen English companies in the field, whose capital aggregated $27,575,000. In 1894 the combine was broken, and all efforts to revive it failed until April, 1896, when one was formed that lasted until April, 1898. In October, 1897, it is reported that thirty-one out of eighty niter works had suspended production. In 1898 it was claimed that the presence of potassium perchlorate in the Chili niter was injurious to plant life, and injured the article as a fertilizer, and that it also injured it for making gunpowder.

A long and fierce controversy was held over the matter, especially in Germany. It is claimed by the manufacturers in Chili that the presence of the potassium was due to too prolonged evaporation of the mother liquors, and that steps were being taken to obviate the difficulty.

Perchlorate of potassium is always present in the mother liquors at the Chili works, and enters the niter in the crystallizing vats if the process is too prolonged, or if the waters are evaporated to a certain degree.

The experiments at Darmstadt show that the perchlorate occurs in Chili niter to the extent of 0.14 to 1.65 per cent.

In 1898 over thirty of the eighty works, or "officinas," remained idle on account of overproduction, and in the same year niter was declared contraband of war, on account of the Spanish-American war. In October, 1900, a combine was organized among the producers, with a five-year contract, beginning April 1, 1901; the allotment for 1901 being fixed at 1,417,233 long tons.

179 CHEMICAL.

The origin of the Chili deposits is discussed at length by Alberto Plageman in a paper entitled "Sobre la formacion jeològica del salitre bajo el punto de vista de la fermentacion quìmica," published in the "Boletin de la Sociedad Nacional de Mineria."

Two theories are advanced, both lacking evidence:

(1st) That the nitrate is the residue of sea-weeds accumulated on prehistoric sea-beaches.

(2d) That it is derived from the decomposition of ancient guano deposits. In Chili the bones, feathers, etc., of birds, are often found in the caliche, giving rise to this theory.

The generally accepted theories among the chemists are that the origin of niter primarily was due to the gradual oxidation by the air of nitrogenous organic matter in contact with the alkali; or that it originates from the oxidation of organic materials and ammonia, accomplished by the action of microscopic organisms known as "nitrifying germs."

In the early history of the United States, saltpeter yards or "plantations" were worked on the Eastern seaboard, and at that time they understood the principle of germ fermentation, for in preparing a new yard it was customary to "silt" it with earth from an old yard (by mother-of-peter, or seed peter), the effect if not the reason being clearly appreciated.

The most favorable condition for the active life and work of these organisms is a porous soil, containing plenty of vegetable or animal organic matter, together with sulphate of lime and an alkaline base (such as carbonate of soda, lime, etc.).

The rate of manufacture will then be greater as the temperature is higher.

In the plains of Tamarugal there is much organic matter, as well as salines. In the Death Valley beds there is a large amount of organic matter, and even ammonia minerals, while some of the springs show the presence of ammonia. In California, as in Chili, the nitrates may be the concentrated fertility of thousands of square miles of desert watershed. Cloudbursts and mountain floods swamp the plains of Tamarugal at intervals of seven or eight years, as similar downpours do the basin of the Amargosa River; and it is the absence of rain during long intervals that permits the accumulation of the deposits.

It is generally conceded that the caliche at Ramirez, in the province of Tarapaca, is the best discovered in Chili, and its chemical composition, according to the analysis of Mr. R. Harvey, A.M., I. C. E., is as follows:

Sodium nitrate	51.0
Sodium chloride	26.0
Sodium sulphate	6.0
Magnesium sulphate	3.0
Insolubles	14.0
	100.0

Analyses from the three main districts, according to Dr. Newton, are as follows:

	1	2	3
Water	2.3	1.9	2.5
Nitrate of soda	50.0	39.3	28.5
Nitrate of potash	0.4	4.8	4.5
Chloride of soda	25.2	26.9	21.9
Sulphate of soda	5.2	2.5	2.7
Sulphate of lime	2.7	3.0	5.0
Sulphate of magnesium	....	5.0	4.5
Phosphate of lime	....	...	0.3
Iodate of potash	....	0.1	....
Iron, Alumina	3.2	1.8	2.2
Silica	10.4	14.4	27.4

It will be noticed in the above that the percentage of sodium chloride (common salt) is next in quantity to the niter. This is the case also in the California beds—the layers that are rich in niter are also rich in salt.

In both countries, the caliche consists of nitrate of soda, with a large percentage of salt, sulphates of soda, lime, magnesia, etc.

In Chili, as in California, large deposits of "salares," or salt beds, exist in conjunction with the niter beds. In Chili caliche varies from 6 to 60 per cent in nitrates; and a "good ground" would be from 3 to 4 feet thick and from 30 to 45 per cent niter, only the high grades being worked in Chili.

180

GEOLOGICAL.

It is evident that niter can only exist in nature in the arid regions, and in order to form it the following conditions are necessary: The presence of alkalies or bases, such as magnesia, soda, lime, etc., in a loose and porous state and easily permeable;

moisture, but not surcharged; unimpeded access of air; and the presence of animal and vegetable matter, and nitrifying germs. As will be seen by referring to the conditions under which Lake Aubury evaporated, as mentioned in the general description of the Great Basin, the conditions were most favorable for the formation of niter beds in what is now known as the Death Valley region; and these conditions were almost identical with those under which the sea that once covered the pampas of Chili was evaporated.

A general section of the Chili beds shows the following:

(1st) "Chuca," or a layer of loose blown dust (Æolian sands) a few inches thick.

(2d) "Costra," a layer of very hard rock from 1 to 18 feet thick. This costra is a conglomerate or pudding-stone in most places, and in others it is porphyritic in character.

(3d) "Caliche," or crude nitrate of soda, the niter-bearing strata being from a few inches to 10 or 12 feet thick. The caliche yields from 3 or 4 per cent up to 60 per cent of nitrate of sodium; over 21 per cent of salt, or sodium chloride; and over 10 per cent of silica and insolubles; besides small percentages of potassium compounds, sodium sulphate, calcium sulphate (gypsum), calcium phosphate, magnesium sulphate, and the iodates of potassium, iron, and alumina.

(4th) Beneath the caliche is a loose gravelly layer, below which no nitrate is found.

181 SIMILARITY OF CHILIAN AND CALIFORNIA BEDS.

Some of the points of similarity between the beds of niter in California and those in Chili may be summarized as follows:

1. Both occur only in the typical hot, rainless desert portions of their countries.

2. Both occur in beds where the niter is associated with gypsum, common salt, glauber salt, sulphate of magnesia, etc.

3. Both are found on the margins of dried-up sea bottoms, or the residuum of evaporated oceans.

4. The Chili beds occur "on the sides of ravines, and in the hollows of the foothills," and "along the edge of the foothills." Those of Death Valley are found in ravines, in the hollows of the foothills, and in the old terraces that marked the former shores of Lake Aubury.

5. The deposits of niter are interrupted in both countries by deposits of salt, borax, borate of lime, soda, etc.

6. The niter beds of Chili are described as varying in breadth,

the "average being 1500 feet," and also as varying in thickness. In California the beds run from 1500 feet to over 2 miles in width, and from 3 to over 6 miles in length.

7. In both Chili and California the caliche varies widely in depth, even in spots close to each other, running from a few inches to several feet.

8. In both countries "spots" are found that are very pure.

9. In Chili the beds are covered with a crust called costra, that is very hard. This costra is composed of the débris of earthy matters cemented together into a conglomerate that contains sand, salt, gypsum, and other salines. In California the beds have a costra of sand, salt, gypsum, etc.; it is not hard but soft, so soft and friable, in fact, that one sinks into it to his ankles. In Chili the costra has to be blasted, while in California it could be removed with a scraper.

10. In both lands there are often layers of boric acid compounds.

11. The colors of the caliche in Chili are yellow, pink, and green. The creamy yellow is the main characteristic of the California beds, but the pink and green are also present.

12. No niter strata are found below the caliche in Chili, while in California nitrates have been found in more than one of the alternating strata of the terraces.

13. In Chili the only nitrate found in commercial quantities is the caliche, or nitrate of sodium. In the California beds, other nitrates have been found, as well as the nitrate of sodium, that promise to be of commercial importance. These are now being investigated.

14. In brief, the niter of both countries was formed under the same geological conditions and on the same huge scale. The chemistry of each is practically the same. In both countries the niter is a peculiar and unique product of their great desert regions.

182 MINING NITER IN CHILI.

In describing the "mining and milling" of the nitrates in Chili, it is convenient to use the terms used there. In the Spanish a nitrate factory is called an "officina"; the crude nitrate as dug out of the earth is called "caliche"; the deposits themselves are known as "calicheros"; the refined nitrate is called "salitre," while the manufacturer is known as the "salitrero."

In order to remove the costra, the native laborers use a sharp crowbar, with which they churn a small round hole down through the hard conglomerate. If the costra is thick, the hole is made large enough to permit the lowering of a small boy, who scoops out a recess at the bottom in the soft caliche. This recess is filled with a slow blasting powder made locally. The explosion shatters the ground for a radius of some 30 feet. A series of holes forms a long trench. The shattered costra is then removed, and the caliche extracted and broken by sledges and steel wedges into blocks that weigh about 30 pounds each. The caliche is hauled in rude carts to the officina, or works, for treatment. In clearing the trench, the costra is thrown back as the caliche is removed forward. If, in one boring through the costra, the caliche is found to be of lower grade than desired, the hole is abandoned and a new spot selected.

The wages paid to the laborers, on the gold basis, are as follows: Day laborer, $.90 to $1.10; shaft sinkers, $1.25 to $1.50; carpenters, $1.50; blacksmiths, $2.00; firemen, $1.50. They work from 6 A. M. to 6 P. M., less one hour for noon. The climatic conditions under which the laborers work are not as good as those of the desert regions of this State. Every officina has its own stores, and supplies the laborer with everything he has, all the wages returning through the stores. The water-supply of the Chili desert is not as good as in the California field.

183 MANUFACTURING PROCESS IN CHILI.

At most of the works the processes and plants are crude. At the large factories, the process is as follows: The 30-pound blocks of caliche are first crushed into two-inch cubes, which are then taken by small cars to the twelve tanks. The caliche is boiled by steam at 60 pounds, until the "caldo" (soup) stands at a temperature of 240° F., and at a density of 110° by the Twaddell hydrometer. It is then settled, and the clear solution of nitrate runs into crystallizing tanks. The "ripios," or refuse, in the boiling tanks is washed with well water, and this water is used again as a mother liquor for dissolving more caliche. The washed refuse is dropped through doors in the bottoms of the tanks and goes to the dump.

After the nitrate solution is cooled and has crystallized, the "agua vieja," or mother liquor, is run to a well, for use again in the boiling tanks. When the nitrate crystals taken from the crystallizing tanks have drained fairly dry, they are shoveled onto drying-boards, where the tropical sun of the desert soon dries them thoroughly. They are then sacked for shipment. The dried crystals contain from 95 to 96 per cent of nitrate of sodium.

Most of the works ship by way of the port of Iquique.

One of the largest nitrate works in the world is the Officina Ramirez, which has a capacity of 200 tons per day. The plant contains six steel boilers, each 30 feet long by 6½ feet in diameter; twelve iron tanks, each 32 feet long by 6 feet wide and 9 feet deep; ninety crystallizing tanks; two feeding tanks; a five-compartment washing tank; three extra circular tanks, 25 feet in diameter by 12 feet deep. The crystallizing tanks are 16 feet square and 3 feet deep. For bringing the caliche to the mill they use two six-ton locomotives; eighty side-dip, one-ton cars; and have two and a half miles of portable railroad track. They also use about thirty mules and five carts.

The process at this officina consists in boiling the caliche at 50 pounds steam pressure in the tanks that are connected in a series of six. The liquor in the boiling tanks is called "caldo," literally "soup," and is run off at 108° to 110° Twaddell. It then contains about 80 pounds of soda nitrate per cubic foot, depositing 40 pounds of it in cooling to 25° in the open tanks. The mother liquor is treated with bisulphite of soda to precipitate the iodine, which amounts to two grams per litre. After this, the mother liquor is sent to a well, to be pumped up and used over again. The work is carried on day and night, arc lights being used.

There are works at Autofagasta that rival the Ramirez in size, and which work on caliche that rarely runs above 20 per cent nitrate, while the Ramirez has a 50 per cent caliche. The entire cost of these works is quoted as £110,000, or about $550,000, each. Especially heavy and expensive foundations increase the cost of works in Chili, to protect them against damage by earthquake.

In spite of these two large works, the work in general among the eighty or more officinas is open to criticism, as shown by Sir William Newton in a lecture before the British Association on September 18, 1896, in which he says:

"In twenty years there has been but little real improvement

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY.

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY—VALLEY OF THE AMARGOSA RIVER.

or economy in production. The style of working which was used in early days in works making a few tons a week, is still employed on a large scale in establishments making 250 tons per day. In the extraction of the crude material expensive borings are made by hand, at a distance of every few yards through the hard costra. Hoists are the exception. The caliche is still carted up hill over loose roads in carts weighing 40 hundredweight, and carrying a load of 45 hundredweight. The boiling is by indirect heat, and is slow, taking from twelve to twenty-four hours per charge, and goes on too quietly to properly stir the muddy residue; so that residue containing as high as 12 per cent of nitrates are often thrown away. All except the softest caliche analyzing 50 to 60 per cent is left in the ground, and the caliche thought properly boiled while the residue still held from 12 to 30 per cent. * * * The supply of nitrates is not enough to last another century at the present rate of consumption."

J. F. Campana, the Chilian Director of the "Delegacion fiscal de Salitreros," or Bureau of Niter Industries, in his report to the Chilian Minister of Finance in 1897 estimated the total amount of available nitrates in Chili as about 73,000,000 net tons, which, at the yearly production of 1,380,000 tons, would be wholly exhausted in fifty-three years, or only half as long as Sir William Newton estimated. The allotment of the "Combine" for 1901 was, however, fixed at 1,417,233 long tons, instead of the estimated 1,380,000 tons. The invention of smokeless powder, and the extension of the use of nitrates in arts and manufactures, show that the demand is increasing faster than is allowed for in the estimate of either Newton or Campana. By referring to the tables of exports of niter from Chili from the beginning in 1830 to the present year, the production is as follows:

	Tons.
1830	8,340
1840	12,000
1850	20,000
1860	100,000
1870	182,000
1880	226,090
1890	1,025,000
1900	1,431,143

At this rate of increase, the Chilian fields will not last as long even as Campana predicts.

184 COST OF MANUFACTURE.

The fuel employed is English steam coal, preferably "West Hartley" or "Orrell." This costs at an officina district 50 miles distant, 55 cents per quintal of 100 pounds. One quintal of coal makes about five quintals of nitrate, or 500 pounds. The export duty on the niter is $1.60 silver, or 38d. per metric quintal of 100 kilos, or 207 pounds, Spanish. Freights to the United States amount to from $6.00 to $6.50 per ton, gold.

The cost of producing a quintal (100 pounds) of niter is given by Alberto Plagemann as follows:

	Cents.
Extraction of caliche	27 to 59
Carting	12 to 23
Concentration	32 to 49
General costs	7 to 12
Various	0.17 to 1.3

Total costs are from 80 cents to $1.42 per 100 pounds, or $16.00 to $28.00 per ton. To the actual cost of niter must be added transportation to port, $4.25, an export tax of about $5.00 per ton, and a freight rate of about $11.00 to Europe.

Another authority claims that at the average cost a quintal (100 pounds) of nitrate may be placed on board ship from a mine 50 miles from port, for $1.25 in gold, or for $25.00 per ton.

These estimates do not, however, check with the valuation placed on the imports into the United States, in which the value per ton is given from $15.34 to $31.08 per metric ton in gold.

While niter is admitted free to the United States, the export duty from Chili is heavy and forms one of the principal sources of revenue of that government, as shown by the official record that from 1878 to 1892 Chili exported 7,496,273 tons, worth $337,182,559, from which the Chilian government collected $158,696,664 in duties (silver).

185

Niter.—Chili Exports.

Year.	Metric Tons.	Value.	Remarks.	
1830	8,340			
1830–1834	16,735			
1835–1839	35,247			
1840–1844	74,180			
1845–1849	95,397			
1850–1854	150,948			
1855–1859	261,049			
1860–1864	323,111			
1865–1868	490,464			
1869	116,065			
1870	182,546			
1871	166,944			
1872	204,676			
1873	290,000			
1874	258,472			
1875	332,917			
1876	338,750			
1877	231,665			
1878	325,139		London Rates.	
1879	146,342	$4,747,529	Lowest.	Highest.
1880	226,090	15,425,558	$66 36	$74 40
1881	358,105	22,891,786	57 60	69 20
1882	495,416	28,698,364	49 20	60 00
1883	593,518	32,043,572	43 80	49 68
1884	562,592	25,163,038	44 20	55 40
1885	438,796	20,654,122	42 84	55 40
1886	453,932	19,230,047	42 40	56 60
1887	722,787	28,690,970	44 00	55 28
1888	784,249	33,866,196	40 20	44 40
1889	921,388	36,387,210	......	......
1890	1,025,617	36,925,414	44 40	47 30
1891	891,727	32,418,491	.....	......
1892	804,213			
1893	943,570			
1894	1,079,000			
1895	1,218,000		U. S. Value per Metric Ton.	
1896	1,088,000	....	$30 39	
1897	1,060,000	....	29 12	
1898	1,254,000	....	15 34	
1899	1,360,000	....	23 42	
1900	1,431,143	....	26 31	
1901	1,417,233	....	....	

186 Niter.—United States Imports.

Year.	Metric Tons.	Value.	Remarks.
1874	28,114	$1,338,141	
1875	23,636	968,855	
1876	23,537	1,055,357	
1877	24,607	1,324,299	
1878	19,126	973,223	
1879	34,607	1,324,299	
1880	30,868	1,830,396	
1881	57,432	2,909,368	
1882	68,178	2,045,127	
1883	58,212	2,469,013	
1884	66,104	2,218,217	
1885	40,632	1,332,969	
1886	63,226	2,373,068	
1887	74,290	2,253,806	
1888	70,233	2,168,607	
1889	76,998	2,500,137	
1890	132,938	3,090,900	
1891	99,663	2,579,930	
1892	96,815	2,933,174	
1893	116,889	3,673,537	
1894	99,594	3,185,356	$31.98 per ton
1895	120,380	3,778,360	31.38 per ton
1896	117,352	3,566,744	30.39 per ton
1897	96,484	2,810,187	29.12 per ton
1898	149,854	2,298,240	15.34 per ton
1899	149,836	3,486,313	23.42 per ton
1900	185,022	4,868,520	26.31 per ton

187 Niter.—United States Exports.

Year.	Tons.	Value.
1890	80	$4,478
1891	106	2,984
1892	217	8,355
1893	2,467	105,624
1894	613	19,819
1895	1,211	44,847
1896	729	24,254
1897	1,009	33,979
1898	821	24,825
1899	2,749	78,877
1900	3,452	112,550

CALIFORNIA NITER.

188
HISTORY.

The existence of niter in the low rolling hills along the Amargosa River has been an open secret for over twenty years, and its existence in the State is no new discovery. The first locations were made as early as 1883 by desert ranchmen, at the instigation of a traveling chemist who was hunting borax. Very little importance was attached to the valuable discovery, and the locations were neglected and allowed to lapse.

Subsequent investigations at different times by other parties shared the same fate.

April 28, 1892, J. M. Forney, a mining engineer of Santa Monica, California, spent some two months in examining the deposits, and his report was published by W. A. Vandercook, of Los Angeles.

From this time on, however, very little was done until 1901, when they passed into the hands of the American Niter Company, the present owners.

One reason why the beds have lain idle and neglected was, that very little intelligent prospecting appears to have been done by any one. The immense hills were sampled in the most superficial way, as explorations in the desert are necessarily expensive, and the explorers were handicapped by lack of both time and proper capital. Difficulty in obtaining accurate analyses was another drawback. If the clews obtained from the numerous analyses had been followed up by capital, these beds would have been worked long ago.

In 1899 interest was again awakened, and since that time considerable progress has been made in the determination of values.

Early in 1901 the American Niter Company was organized, and most of the time has kept men in the field, surveying and analyzing the deposits.

189
LOCATION.

Nearly all the niter beds, so far as discovered, are situated in the northern part of San Bernardino County, and extend across the boundary line into the southern part of Inyo County. They are found along the shore lines, or old beaches, that mark the boundary of Death Valley as it was during the

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY.

NITER BEDS, UPPER CAÑON DISTRICT, INYO COUNTY.

Eocene times. The few outlying beds so far discovered are also located along the beach line of some one of the numerous lakes that were formed by the drying-up of Lake Aubury.

190 APPEARANCE OF THE NITER BEDS.

The beds and clays of the later Eocene deposits, which contain the nitrates, have been worn by erosive agencies into knobs, buttes, and ridges that have been compared by some to gigantic "haystacks" and "potato hills." They have a soft, rounded surface peculiarly their own, and this, united to their creamy-yellow color, enables one to identify them readily even with a field glass in the distance. The size of the "hills" varies from only 50 feet high and covering two or three acres, to those 300 feet or more in height and covering nearly a section of land.

The accompanying photographs will give a better idea of their form than any pen picture. In some nooks and corners, however, the rounded appearance of the beds has been broken up into "ridges," "furrows," or even into castellated and pinnacled forms that remind one of the "ruined cities of the Bad Lands of Dakota." This general description applies to all of the beds, the Owl Spring, Saratoga, and Cañon beds differing only in the preponderance of certain forms of the "hills," "furrows," or "castles," and in variations of the shade of "creamy-yellow."

191 DEATH VALLEY.

The dry lake, usually marked "Death Valley" on the maps, is only the portion considerably below sea-level, and is but a small area compared with the valley proper, which consists of immense inclined planes starting from the ancient shore lines and dipping toward the lowest depression from all directions.

Death Valley proper begins at the mouth of the Amargosa Cañon, 10 miles south of Willow Creek ranch, its eastern limit being at Salt Springs on the old emigrant road to the Sink of the Mojave River.

The south end of the valley is inclosed by the Kingston Mountains on the east, by the Avawatz on the south, by the Owl on the west, and by the Funeral range on the north. The Amargosa

River heads in Nevada, its main branches coming in from the Amargosa Mountains. It flows in a southerly direction for about 120 miles to the boundary line between Inyo and San Bernardino counties, where it enters its cañon, some 6 miles long, emerging from it on this edge of Death Valley. On entering the valley, it makes a wide sweeping curve to the north, passing Saratoga Springs, and entering Inyo County again some 20 miles west of the cañon.

The north extension of the valley proper is known as "Lost Valley," and reaches from the mouth of Furnace Creek to the north boundary of Inyo County.

To gain some idea of the vast drainage basin whose waters flow to Death Valley, it is only necessary to state that the head of the Amargosa River is in Nevada, over 280 miles northeast of Saratoga Springs; that the Mojave River heads in the Sierra Madre Mountains, 150 miles to the southwest, and that a rise of water of less than 20 feet would carry the water of this river into Death Valley by way of Salt Springs and the South Fork of the Amargosa River.

192 GEOLOGY.

The geology of the Great Basin in general has already been given. At the niter beds around the margin of Death Valley the following points will be noted:

The underlying rocks of the districts are the slates and schists of the Jura-Trias period, highly metamorphosed as the result of the intense volcanic action that has scattered lava throughout the district.

Next above are the Eocene-Tertiary clays, deposited during that long period of subsidence. They appear as some 800 feet of clay bedded on the upturned edges of the older rocks in horizontal and undisturbed strata, having a peculiar creamy color. In some places gravels of the Champlain epoch appear.

This gravel, spreading like a mantle over the whole country, covering and completely hiding the underlying strata, was carried there during the great Champlain epoch to the depth of from 1 to 150 feet. It is only where the erosive forces of nature have washed away the top cover of this alluvial that the clay beds appear below. How far they may extend underneath the gravel, their depth and condition, are conjectural and can not definitely be stated at present.

193

THE CLAY HILLS.

The formation of the niter-bearing clay hills occurred, undoubtedly, in the Eocene-Tertiary, during the long intervals of subsidence characteristic of that period, and are the result of sedimentary marine deposits slowly accumulating in layer after layer of fine clays to a depth of probably a thousand feet or more, bedded on the upturned rocks below in horizontal strata, and subject to very little disturbance since their deposit.

The perfect stratifications reposing conformably in their original positions show the different layers to be from 6 inches to 10 feet in thickness.

These clays in their dry state are very hard and compact, resembling gray and brown-gray lithographic stone. When pieces are placed in cold water, they soon melt into slime, the salines going into solution and the alumina and silica settling down, leaving the solution clear. This action is very plainly visible on top of some of the hills, where water from the rains has sunk down until finally a channel, that is like a shaft, penetrates the center of the hill. In other places the waters have formed long tunnels through the hills.

194

CALICHE.

Until recently, the whole value of these niter hills was supposed to lie in the surface coating, for when the top scale a few inches in depth was shoveled off, or even pushed aside with the foot, layers white with salines were exposed. This top coating is unique, and the Spanish term "caliche," borrowed from the Chilians, is most convenient for describing the top coating as distinct from the stratified layers.

This caliche ranges in depth or thickness from a few inches to several feet.

The caliche of the niter beds is a formation of considerable thickness and volume found a few inches, or a few feet, beneath the surface of the terrace deposits of Death Valley as it existed in ages past.

The surface of this top crust or layer is comparatively smooth, giving a soft, rounded appearance to the hills into which the ancient terraces have been worn by erosion.

While the top is smooth, the lower portion under the surface crust is irregular, earthy, porous, and blends gradually

NITER BEDS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

NITER BEDS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY—THE OLD BEACH LINE OF DEATH VALLEY, FUNERAL RANGE, BORAX FLAT, AND SARATOGA SPRINGS IN BACKGROUND.

with the stratified layers below. While the caliche surrounds and includes sand grains, gravels, and more or less earthy material, it seems to have had the power, especially in its upper crust, of extruding the coarse materials of the soil to a great extent. It roughly conforms to the general surface, rising and falling with the contour of the hills. There are, in places, repetitions of the layers, separated by a few inches, or a few feet, of more earthy deposits.

The Death Valley region is characterized by the unusual dryness of the air and its capacity for the absórption of moisture, and the maintenance of continued evaporation from the soil, which determines a constant upward movement of the phreatic water. The light showers of midsummer and mid-winter do not penetrate to great depths, but are sufficient to leach the soil to a certain distance, turning the saline solutions backward and downward, and producing the denser upper crust where it meets the upward flow.

While the hills which it covers are composed of layers deposited during the desiccation of Lake Aubury and later by the desiccation of greater Death Valley, the caliche was not directly deposited from such waters, but is of later origin. The surface caliche is clearly the result of the upward capillary flow of water from below, induced by the constant and rapid evaporation at the surface in a comparatively rainless region. It is not the result of a flow from springs, or from any source at the surface, or by the lateral movement of water; but is an example of concentration, by evaporation at the surface, of the solutions of nitrate of soda that were deposited in the desiccation of Lake Aubury in the layers of the terraces. The caliche is a fine example of the formation of extensive strata in the midst of preëxistent beds, not by metasomatic processes, but by precipitation from sources below.

The niter itself is a very soluble white crystalline salt that readily permeates the clays. In the gradual process of erosion, which has been going on for ages, and in the wearing away of the clays by periodical rains and floods, the nitrate, upon solution in the upper layer, would immediately be taken up and held by the strata below it, and so on in rotation, through the long period of years, thus making the hills themselves concentrators and never allowing one iota of this salt to escape, until the hills were either leveled with the plain, or the niter lying on the slopes would come in contact with the flow of water at their base, in which case it would be dissolved and swept away. The tenacity of this clay to hold and retain the niter is shown by the fact that the surplus of any strata, as soon as dissolved, and flowing down the slopes, would be greedily taken up by every clay seam with which it came in contact, thus covering, at different angles, all the horizontal layers of the hills; the loose matter on top protecting and preserving it, never allowing the rains to come in direct contact with the salt.

The surface deposits of the soluble salts, such as the chlorides (common salt), sulphates, and carbonates, are similar concentrations by evaporation at the surface of similar solutions.

The colors of caliche in Chili are yellow, pink, and green. The creamy-yellow is the characteristic color of the California beds, but the pinks and greens are also present.

195 THE STRATA.

As it is evident that the niter in the caliche is ever being drawn from below, as the process of erosion goes on, the question at once arises, "What do the clay layers that form the body of the hill contain?"

Unfortunately, this question can not be answered fully at this date. The huge hills show abundant faces where the strata are exposed for a vertical height of from 50 to over 200 feet. Many samples have been taken from the layers where accessible, and such samples give by analysis all the way from traces to as high as 50 per cent of nitrates; but only pieces can be broken off from favorable edges and corners, as the clays are too hard to work with a pick and must be blasted.

Camps must be built and miners employed to penetrate the hills before the character of the interior is known. The pits and shafts of 10 feet or less in depth show the surface values, but give no information as to what lies beyond.

The accompanying photographs show the existence of huge outcrops of salines, showing on what an enormous scale nature was at work. They show a vein or bed of rock salt over 15 feet thick, that is overlaid and underlaid by some 50 feet or more of salt mixed with sand and clay, that outcrops for half a mile in length; immense beds of borates; large beds of soda carbonates, etc.; and it is but natural to expect that when the lands are thoroughly prospected, certain strata or layers in the body of the hills will be found to be far richer than any of the weathered surface. This is evident also, if one considers again the origin of the beds.

196 ORIGIN OF THE BEDS.

The mud beds of the Eocene carried and contained the enormous amount of animal and plant life, the decomposition of which, after the water receded, made the nitrates of to-day. Nitrification is the process of fermentative oxidation, which always sets in when moist nitrogenous animal or vegetable matter is left to itself, in the presence of air and any basic substance.

The oxidation of the nitrogen of the atmosphere is also promoted thereby, and associates itself readily with any azotized decomposed organic substance, adding its portion to the mysterious chemistry of nature. The artificial niter farms of Europe are proof that this theory regarding the origin of nitrates is, in the main, correct.

As organic life was not evenly distributed throughout all the different strata of these mud beds, it will naturally follow that some layers of clay will simply show traces of niter, while others, perhaps, above or below them, will yield percentages equal to those found in the beds of Chili. It is expected that the work of the coming season will answer many of the questions that might be asked.

The points of resemblance between the Californian and the Chilian beds have already been given in paragraph 181.

197 DIFFICULTIES IN SAMPLING.

The difficulties in the way of sampling these vast fields can hardly be appreciated by those who have not visited them.

They are, as yet, so far from the railroads that one can not visit them, even for a few days, without a large and expensive outfit, for one must carry bedding, tents, and food for man and animals.

Without cabins where supplies can be stored, it is impossible to carry supplies for more than one month's stay without having supplies sent out; and, while out, most of the time is consumed in traveling.

Given one level claim of 160 acres, and it would not be easy

MORRISON'S RANCH ALSO KNOWN AS THE CHINA OR EVANS RANCH, UPPER CAÑON DISTRICT, WILLOW CREEK, INYO COUNTY.

NITER HILLS LOWER CAÑON DISTRICT, SAN BERNARDINO COUNTY.

in a day's time to sample the surface to a depth even of 2 or 3 feet; but each niter district is made up of from twenty-five to forty claims, each of 160 acres, and instead of being level is a jumble of hills, 200 or 300 feet high, and the difficulties are multiplied accordingly.

With only tents to live in and work in, it is impossible to do the chemical work in the field; and with so many questions arising, it is not satisfactory to take samples to be analyzed weeks after, for one ever wishes on certain samples to go back and investigate that particular place, hill, or stratum again, and at once. It is not to be wondered at, then, that nearly all the work so far done has been mainly on the surface caliche.

The definition of the most valuable areas, and approximate estimates of quantities and values, can only come after camps are built and a force of men have been at work for months in the field; but it may be said that the wide distribution of the niter, and the many high analyses obtained, fully warrant this full investigation.

198 CHEMICAL ANALYSES.

Analyses of samples from over 200 claims show that the following minerals are associated with the niter in varying quantities: Chloride of sodium (common salt), sulphate of sodium (glauber salt), sulphate of lime (gypsum), sulphate of magnesium (epsom salt), and iodine compounds.

In some of the niter districts the chloride, sulphate, and carbonate of sodium exist in beds and deposits of large extent, as mentioned elsewhere.

The following analyses are printed simply to give some idea of the variations in the proportions of the various salines:

Death Valley Niter.

	1	2	3	4	5
Niter	7.28	14.50	27.40	46.50	61.20
Chloride of sodium	6.36	7.56	21.15	25.30	16.40
Sulphate of sodium	.60	.70	2.05	5.30	3.10
Sulphate of lime	.20	.10	1.04	.30	.20
Sulphate of magnesium	1.30	2.80	2.00	1.20	1.20
Insolubles	84.26	74.34	46.36	21.40	17.90
	100.00	100.00	100.00	100.00	100.00

No potash has been found as yet in the beds. The insolubles include iron, alumina, and silica.

199 ANALYSES OF CALICHE.

A summary of some of the analyses of the caliche, or surface coating, only of some of the hills, was as follows. Note that the analyses are not ultimate analyses of the caliche, as the percentages of niter given are only those extracted by boiling in water for half an hour. The percentage of niter in the residues was not determined:

Upper Canon Beds.—Highest per cent of niter, 21; lowest, 0.3. Average of 24 analyses, 8.98 per cent.

Lower Canon Beds.—Highest per cent of niter, 12.90; lowest, 0.67. Average of 14 analyses, 4.77 per cent.

Saratoga Niter Beds.—Highest per cent of niter, 32.72; lowest, 1.52. Average of 34 analyses, 9.4 per cent.

Owl Springs.—Highest per cent of niter, 67; lowest, .38. Average of 18 analyses, 17.2 per cent.

Tecopah.—Two samples gave 6.85 and .38 per cent of niter.

Valley.—Highest per cent of niter, 11.41; lowest, 1.52. Average of 5 samples, 8.3 per cent.

Confidence.—Highest per cent of niter, 1.90; lowest, .76. Average of 4 samples, 1.7 per cent.

Round Mountain.—Two samples gave 15.6 and .76 per cent.

Salt Springs.—One sample gave 3.04 per cent niter.

In all the analyses given above, each sample came from a separate claim of 160 acres.

The average from 104 samples of caliche taken from 104 claims was 9.54 per cent of niter. These analyses show that the niter exists throughout the district; but can not be taken as the final averages, owing to the difficulties in the way of sampling, as already mentioned.

200 ANALYSES OF STRATA.

Specimens of the clay strata have been collected and a number of them analyzed, sufficient to show the fact that some of the strata carry from 15 to over 40 per cent of niter, and that a thorough investigation of the field promises to show the existence of bodies of the stratified clays that will pay to work on a commercial scale.

201

QUANTITIES.

It is impossible to give the exact acreage of lands located for niter, but the following will give some idea of the extent of the beds:

The number of acres located in the Owl district is over 6000; Saratoga district, over 8000; Upper Cañon, about 4000; Lower Cañon, about 3000; Round Mountain and Valley, over 3000; Confidence, 2500; Salt Springs, about 3000; Tecopah, 2500; Pilot, Danby, Needles, and Volcano, 3000; a grand total of about 35,000 acres.

In order to form some idea of the possible value of the fields, one may consider the caliche alone for a moment.

The minimum thickness of this surface niter is 6 inches. One acre of ground contains 43,560 square feet; this at 6 inches of depth is equal to 21,780 cubic feet; this at 70 pounds per cubic foot amounts to 1,524,600 pounds, or 760 tons, per acre, say 750 tons; 30,000 acres (allowing 5000 acres as rejected) at 750 tons amounts to over 22,000,000 tons.

In some places the caliche is known to be from 3 to over 5 feet in depth, and the acreage of the coatings of the high hills is considerably more than if the ground were level, as in the above figures. When it is remembered that some of the strata from 3 to 10 or more feet in thickness have been found to contain values from 15 to over 40 per cent of niter, it will be seen that the quantities are sufficient to attract the attention of the largest capitalists and to lead to their full exploration and development.

202

VALUES.

No attempt will be made to place a value upon these niter beds, based on tonnage or average per cent per ton. The facts so far as obtained show the existence of quantities on a scale large enough to be of national interest. The analyses show that niter exists on some of the claims rich enough to rival the beds of Chili.

During the coming year the parties in the field will give their attention to detailed study, exploration, and development of the fields; selecting, so far as possible, the best locations in which to define and measure areas and quantities, and to ascertain the commercial values of the same. The next step then will be to work out the best methods of treating the material in factories.

NITER BEDS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY. DEATH VALLEY IN DISTANCE.

NITER BEDS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY. DEATH VALLEY IN DISTANCE.

203 MINING AND MANUFACTURING.

The methods used in Chili have already been broadly noted, but these methods are open to much severe criticism as crude and wasteful. While it is too early to outline any specific methods that may be used, there is no doubt but that "Yankee" ingenuity and skill will improve greatly upon Chilian methods, and the result will be that material as low as 6 or 7 per cent in niter will be utilized. At first, of course, only the higher grades will be selected and worked.

At Daggett, borate muds running as low as 5 per cent are sent through the Bartlett and Humphries works, and they by no means claim a perfect process, in either plant or manipulation. In Chili, residues containing 10 per cent, or over, of niter are wasted. The niter beds are not "poor men's mines," but will require large capital and the best technical and chemical skill. With such applied to them, a new industry of importance to the nation, as well as to the State, will be fairly started.

204 WATER-SUPPLY.

The whole question of water-supply for manufacturing is one of moderate expenditure for developing the existing springs, and for artesian and dug wells. There is ample water below the surface of the desert valleys.

205 CLIMATE.

July and August are too hot for outdoor work, and Death Valley proper, at that time, is dangerous. During the rest of the year its climate is like that of The Needles, California; Yuma, Arizona; Daggett, Salton, and other places on the western desert where large populations exist. From early in October to April the climate is good, as is that of any part of the western desert. The high winds that blow in the spring and fall may be trying at times to the unprotected traveler, but where houses exist they are easily avoided.

206 TRANSPORTATION.

The coming year will show where the main lines of road will cross the desert and settle this question. Some of the surveys already made pass through the niter districts.

207 ## RANCHES.

The Willow ranch (also known as the China, Evans, and Morrison ranch) is located on Willow Creek in the Upper Cañon beds. Hay, both barley and alfalfa, is raised here in considerable quantities. Anything raised in Southern California can be raised here. This place, and Lee's at Resting Springs, show what can be done if the land is irrigated. Numerous photographs made show, better than words, the capabilities of the land. These ranches are occupied during the year through.

With the development of the niter, and the utilization of the present water-supplies, ranches will spring up in many places, forming oases in the desert. In this respect the niter fields of California have a great advantage over the extremely arid fields of Chili.

MINERALOGY.

208 **Soda Niter.**—Nitrate of soda; cubic niter; niter; Chili saltpeter; caliche. Nitric acid, 63.5; soda, 36.5. Color, white, also reddish brown, gray, and lemon yellow. Hardness, 1. Specific gravity, 2.24 to 2.29. Blowpipe deflegrates on charcoal with less violence than niter, giving yellow light; also deliquesces. Flame intensely yellow. Dissolves in three parts of water. Taste, cooling. Found in Inyo County in the Confidence, Tecopah, and Upper Cañon beds; and in San Bernardino County in the Valley, Round Mountain, Saratoga, Lower Cañon, Salt Springs, and Owl Springs beds, and as crystals lining a cave in the Calico district.

209 **Potash Niter.**—Niter of potash; saltpeter; salitre. Nitric acid, 53.5; potash, 46.5. Color, white. Hardness, 2. Gravity, 2.09. Deflegrates vividly on burning coals. Color, flame violet. Taste, saline. Found in the desert northeast of Salton, Riverside County.

210 **Nitrocalite.**—Hydrous nitrate of calcium. Occurs on efflorescent silken tufts and masses. More common where the soil is calcareous. Taste, sharp and bitter.

211 **Nitromagnesite.**—Nitrate of magnesia. In white efflorescence. Taste, bitter.

212 **Nitrobarite.**—Barium nitrate. Nitric acid, 41.4; baryta, 58.6. Colorless.

213 **Gerhardtite.**—Nitrate of copper. Color, emerald green.

214 **Darapskite.**—A nitro-sulphate of soda. Nitric acid, 22.0; sulphuric acid, 32.7; soda, 38.0; water, 7.3; or sodium nitrate, 34.7, and sodium sulphate, 58.0. Colorless, transparent. Water is expelled by heat without decrepitation. Found in the niter beds of Death Valley, Inyo and San Bernardino counties.

215 **Nitroglauberite.**—A nitro-sulphate of soda. Nitrate of sodium, 60.1; sulphate of sodium, 33.5; water, 6.4. In white homogeneous mass with fibrous crystalline structure. Found in the niter beds of Inyo and San Bernardino counties.

THE NITER DISTRICTS.

INYO COUNTY.

216 **Upper Canon Beds.**—The locations here cover 3880 acres of land, along both sides of the Amargosa River and Willow Creek. The ranch of Dave Morrison (also known to desert men as the "Evans," and "China" ranch) is located on Willow Creek, in the center of these beds. The initial point of the surveys by which the locations are governed is a boundary monument between the counties of Inyo and San Bernardino, on the Amargosa River. This monument was erected in 1876 by the official survey. The photographs show, better than any description, the huge dimensions of the clay niter hills of this district; the deep ravines; the soft coating of caliche; the strata of saline clays; and the enormous erosion to which the whole has been subjected. Along the Amargosa River, about one mile west of the ranch, large flats have been made by the melting away of the clay hills; the waters of the river having evidently been backed for a long period, until it could cut its way through the eruptive strata of Merrill Mountain, at the mouth of Willow Creek.

Around the outer boundaries of the beds the stratifications of clays are coarser, the color more of a light gray, the percentage of silica increases, and gravel even is found in the strata, until they shade into sandstones. Limestones and tufas are also found around the outer boundaries of the niter district. In the outer rim, these tufas may be found alternat-

NITER HILLS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

NITER HILLS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

ing with clays and sandstones, forming cliffs several hundred feet high, and capped by alluvial drift.

This tufa has evidently been deposited at the same time, but has no further bearing upon the niter, containing mostly silica. It is of the pumiceous variety and the result of comminuted volcanic rocks. In color it is a dead white, somewhat oolitic in structure, very light, making a good building-stone, for which purpose it is largely used by the settlers. The nature of this volcanic conglomerate is well understood, and represents the remains and fragments of lava knitted together by aqueous action and deposited as a sediment during submersion. In some places, numerous strata of gypsum cross and recross the clays in all directions, forming sometimes distinctly traceable ledges, six inches thick, of transparent plates called "selenite."

Another variety, "satin spar," pure white, and delicately fibrous, is also met with in nearly all the beds in small quantities; this gypsum, together with common and glauber salt, being the ever accompanying elements of the nitrates. Traces of free iodine are also found, but not sufficient to warrant attention.

In confirmation of every evidence as to real age of these deposits, the valuable discovery by Mr. Unthank of the remains of a mammal, embedded in the clay, forms a very important factor. It was found about half a mile west of the ranch, in a dry watercourse, on the side of a worn-away stratum. The body of it had disappeared, and only the head remained, whose enormous dimensions were still plainly to be seen in the space it had once occupied, but the decay of ages had done its work so thoroughly as to leave nothing but a fine dusty powder behind; the few crumbling pieces of the skull and jaw, two incisors and four large molars, were all that could be recovered, and they were carefully packed up and preserved for future reference. This animal, according to standard authority on that subject, is called a Palæotherium, and belongs to the Herbivoers of the early Eocene, forming the connecting tie in the serial line of progression and marking the pedigree of the horse family of to-day, holding equal claim of being the true progenitor of the Tapiroids.

217 **Tecopah.**—This niter district received its name from the old Indian chief who lived for years in this region. It is located just north of the south line of Inyo County, on the head of

NITER HILLS, SARATOGA DISTRICT, SAN BERNARDINO COUNTY.

NITER HILLS, SARATOGA BEDS, SAN BERNARDINO COUNTY.

Willow Creek, and is about 11 miles east of the Upper Cañon beds. The location covers 2560 acres. These beds are partially buried under the Quaternary gravels, and appear as a large playa lake cut by erosion into low, rounded hills. These beds are known to contain borates in quantity, and show the existence of nitrates.

As these beds were only located in 1901, they have not been explored to any extent.

218 **Confidence.**—These beds are situated along the south side of Death Valley at the "Narrows," about 30 miles west of Saratoga Springs. They take their name from the old Confidence gold mine, a mine worked over twenty years ago by the Mormons. The wreck of their old mill stands in the valley about 4 miles north of the niter hills. The locations here cover 2400 acres. The clay hills here are equal in size to any of those in the other districts. The noticeable feature is that they have been protected, by their position, from erosion and have very few ravines and gulches, and show but few exposures of the underlying strata. The locations were made last year and the beds have not, as yet, been developed. The presence of the same minerals as in the other beds has been noted, noticeably the large percentage of "natural sodas."

SAN BERNARDINO COUNTY.

219 **Upper Canon Beds.**—The Upper Cañon beds of Inyo County, already described, extend south of the county line, half a mile into this county.

220 **Lower Canon Beds.**—These are located in the side of the Amargosa River Cañon, about 4 miles south of the Upper Cañon beds, with which they were once connected; the intervening portion has been eroded, as clearly shown by the small patches remaining in a few places. The hills present the same general appearance as those north of them, excepting that they are more rounded and softer in their general outlines, and show fewer vertical faces and narrow cañons. There are more of the red clays in these hills than in the northern ones, and all of the red clays seem to be richer in niter than the gray-colored; but further developments may not sustain this suggestion. The locations in this district cover some 2720 acres.

HARD STRATA, NITER HILLS, WILLOW CREEK, INYO COUNTY.

HARD STRATA, NITER HILLS, UPPER CAÑON DISTRICT, INYO COUNTY.

Good wagon roads from the main road along the Amargosa penetrate to the centers of both the upper and lower districts.

221 **Salt Springs.**—The Salt Springs district is located about 20 miles south of the Willow Creek ranch, about 10 miles south of the end of the Amargosa Cañon, on the South Fork of the Amargosa River. The locations cover 2880 acres. At the pass, at the west end of the district, and at the east end of Death Valley, are large salt springs that give the name to the district. The old Salt Lake (Utah) emigrant road that came down the Amargosa River to Death Valley left the valley at this pass, and going around the east end of the Avawatz range passed south to the Sink of the Mojave.

A brief geological examination of the district is sufficient to show that the waters of the Mojave River, in comparatively recent times, entered Death Valley through this pass. This district at first resembles only an extensive level playa lake, and only travel over it gives any idea of the depth of the deposits. The clays have the same creamy color and soft texture as the "hill" fields, and the same general chemical composition.

Having only been located in 1901, but little development work has been done upon them.

222 **Saratoga.**—The Saratoga beds form the main portion of a partially eroded beach that lies at the junction of the Avawatz range and Death Valley. These beds extend along the north flank of the range for some 6 miles, and in some places are a mile in width, the locations selected covering over 5600 acres. The panorama photographs show clearly the beach structure and the general character of the hills, which exist here on even a grander scale than those of the cañon districts. The road from Daggett to Death Valley, by way of Cave Springs, passes along the extreme west end of the district; while the road from Johannesburg to Saratoga Springs passes through the eastern portion of the beds.

Saratoga Springs, well known to every desert traveler, are located at the west end of the Funeral range, about 3½ miles north of these niter beds. While no wagon roads have been constructed through the district, it is possible to drive a light wagon among some portions of the hills by following up some of the numerous "washes."

The clay hills run from one to nearly three hundred feet in height, and in general have the same soft rounded outlines as in the Cañon district. They do not, however, as a rule, show the underlying strata so well as at the Upper Cañon. The eastern end of the district contains unlimited supplies of salt, in the form of hard salt crusts from 3 to 10 feet thick, and also beds of rock salt. One of these beds of rock salt is exposed for a thickness of 16 feet and outcrops for half a mile along the gulch. It is probable that by blasting through the heavy crusts beds of rock salt may be exposed in many other places in this district.

The rock salt vein exposed is of a reddish tinge, hard, and comparatively clear. A specimen analyzed gave over 95 per cent of chloride of sodium. Thick and extensive beds of borates are found throughout this district, borates of lime predominating. Veins of sulphate of lime, in the form of gypsum, selenite, and satin spar, are common everywhere in this district, as they are, in fact, in all of the niter districts.

The western end of the district contains less salt crust, and the caliche is softer than at the eastern end.

In the central portion there are large areas rich in the carbonates and sulphates of soda. This field promises to become one of the centers of activity, not only on account of the niter, but also from the other valuable salines it contains. It is centrally located, and artesian wells in the valley promise abundant water, as well as that already supplied by the river and springs of the valley.

223 **Round Mountain.**—This district, which is only one mile square, is located just beyond the western end of the Saratoga beds, of which it was once a portion, and therefore needs no specific description.

224 **Owl Springs.**—This district is on the road from Johannesburg to Death Valley, about 20 miles southwest from Saratoga Springs, and 18 miles northeast from Leach's Spring. It occupies the head of the valley between the west end of the Avawatz range and the east flank of the Owl Mountains. The district takes its name from the well-known "Owl Holes," or Owl Springs, that are located in about the center of the district. The locations selected here cover 6080 acres.

The niter hills of this field are still partially covered by the Quaternary gravels, the tops of the clay hills showing from

25 to 100 feet above the gravels in many places. As the field lies near the top of the divide, it has been more protected from erosion than the other fields. The southwestern, or higher, portion of the district is especially rich in colemanite and other borates, while the northeastern, or lower, portion is rich in large deposits of rock salt and heavy salt crusts. The caliche of this field, in general, is not so soft and friable as that of the other fields, but carries sufficient salt to make the surface difficult to penetrate with a pick. In other respects the hills resemble the other districts.

225 **Valley.**—This district is located on the north rim of Death Valley, about 12 miles west of Saratoga Springs. While the hills are not high, from 25 to 100 feet, the caliche is soft and thick and looks promising. The locations cover 2560 acres of ground.

A noticeable feature is the outcrop of large deposits of soda carbonates at various points in the hills. The Amargosa River rises to the surface at one point among the hills, forming what are known as the Valley Salt Springs. That they are due to a local rising of the river water to the surface is plainly to be seen, as half a mile below the springs a dike of volcanic rock may be seen crossing the valley, shutting off the underflow, and forcing the waters to the surface. The "springs" are large in volume, flowing probably in the dry season over 1000 miner's inches of water, and forming a salt marsh nearly a mile long. The water is a heavy salt brine, as shown by the analysis given under "Chlorides." These beds were located last year and are as yet undeveloped.

226 **Pilot.**—The Pilot niter district is located on the old beach line east of Searles Lake, at the south end of the Slate range. It takes its name from Pilot Peak, a famous landmark of the desert that is about 20 miles south of this district. The locations are similar in general detail to those already described in Death Valley.

Searles Lake is the main depression, or sink, left by the evaporation of the ancient lake that once filled what is now known as the Panamint and Salt Wells valley, and whose terraces may be found 600 feet or more above the well-known borax lake. The local conditions were such that the beach lines of this great lake suffered more from erosion than did

"DESERT LINING," SARATOGA SPRINGS, SAN BERNARDINO COUNTY.

SLIDING DOWN A NITER HILL, SAN BERNARDINO COUNTY.

Death Valley, or more of the soft clay niter hills would be found around its margins.

227 **Calico.**—As early as April, 1883, considerable excitement was created by the discovery of niter near the town of Calico, a few miles north of Daggett. The find proved to be only an efflorescence along some small seams and rock cavities, and an incrustation in a small cave that gave some good cabinet specimens. Nothing of any extent or commercial value has as yet been found.

228 **Danby.**—The existence of niter has been reported as discovered in the playa deposits near the salt beds at Danby Lake, and locations were filed upon the land in 1901; but no development work has been done, and no analyses are at hand at the date of this bulletin.

229 **Needles.**—Clay hills of considerable extent that carry niter in commercial quantities are reported as existing in the mountains on the west side of the Colorado River, about 30 mlies south of the town of Needles. Locations covering about 300 acres were made during the last year, but no development beyond assessment work has been done. Analyses of specimens brought in show from 14 to 40 per cent of niter in clay strata.

SAN DIEGO COUNTY.

230 **Volcano.**—Locations covering 4800 acres have been made along the old beach lines east of the Mud Volcanoes, in Township 10 South, Range 14 East, S. B. M., in this county. The few specimens brought in gave from 3 to 5 per cent of niter, but gave little information as to the possible value of the discovery. The locations having been but recently made, their value can not be shown until development work has been done.

NITER ANALYSES.

The following analyses are selected from a large number placed at the disposal of the State Mining Bureau, and are given for the purpose of showing the general character of the results obtained by many different prospectors.

In no case have two of the different chemists quoted analyzed the same sample.

231 UPPER CANON BEDS.

Analysis of surface material, by *Hite Wickizer*, of Los Angeles, California:

Nitrate of soda	8.1
Chloride of soda	6.9
Sulphate of soda	4.0
Nitrate of potash	trace.
Soluble	19.0

Analysis by the *Bradley Fertilizer Company*, of Boston, gave "Nitrate of soda, 7.25 per cent."

The following analyses of surface material were made by *Thomas Price*, of San Francisco, over ten years ago:

Nitrate of Soda in Earths.	Nitrate of Soda in Salts.	Nitrate of Soda in Clays.
8.70	49.64	15.54
31.75	33.14	7.83
14.50	10.03	3.06
2.50	22.95	4.57
3.10	8.09	2.10
3.50	8.92	1.87
2.80	5.81	1.97
5.30	15.38	3.89
	23.20	3.05
	46.75	10.58
	54.57	14.18
	55.42	11.63
	31.11	7.80
	21.67	5.53

Analyses by *G. E. Bailey* and *Prof. Will C. Bailey*, of San Francisco:

Upper Canon "Caliche."

Nitrate of Soda.	Chloride of Soda.	Sulphate of Soda.	Other Salines	Insoluble.
5.32	4.40	.05	.73	89.5
14.50	7.56	.07	2.87	75.0
18.25	13.76	.06	2.93	65.0
17.50	5.67	.09	7.24	69.5

Upper Canon Salts.

Nitrate of Soda.	Chloride of Soda.	Others Not Determined.
12.5	84.0	
50.6	47.9	
40.9	47.6	
58.0	30.0	
52.1	39.0	
68.4	19.0	
57.0	30.0	
60.0	22.0	

232 LOWER CANON BEDS.

"Caliche."		Salts.	
Nitrate of Soda.	Chloride of Soda.	Nitrate of Soda.	Chloride of Soda.
6.46	5.88	15.2	51.6
4.60	3.44	43.0	29.0
12.90	8.94	46.0	34.0
7.20	5.84	48.0	38.0
10.60	10.49	48.5	49.1

233 SARATOGA BEDS.

"Caliche."	Salts.
Nitrate of Soda.	Nitrate of Soda.
3.04	20.2
5.70	57.0
10.22	47.0
14.45	65.6
25.87	93.5
32.72	57.4
28.15	

234 OWL SPRINGS.

"Caliche."	Salts.
Nitrate of Soda.	Nitrate of Soda.
1.14	85.0
6.85	45.1
27.40	95.7
14.45	93.2
32.72	71.5
22.21	87.0
35.76	

235 NITER IN FERTILIZING.

All plants require light, air, heat, water, cultivation, and a fertile soil. Every crop removes from the soil a portion of the plant-food contained therein, and continuous cropping will, in time, exhaust the richest soil, unless the nutritive elements are restored; therefore, the truly economical farmer will feed the growing plant or tree with a generous hand. The literature on this subject, while voluminous, is so scattered as to be difficult of access to the general reader, and the following notes are added in order to give some general idea of the value of nitrate of soda in fertilizing.

The most important materials used to supply nitrogen, in the composition of commercial fertilizers, are nitrate of soda and sulphate of ammonia. Nitrate of soda is particularly adapted for top dressing during the growing season, and is the quickest acting of all the nitrogenous fertilizers.

Dried blood, tankage, azotine, fish scrap, castor pomace, and cotton-seed meal represent fertilizers where the nitrogen is only slowly available, and they must be applied in the fall so as to be decomposed and available for the following season. Nitrogen in the form of nitrate of soda readily leaches through the soil and is at once available during the growing and fruiting season, possessing, therefore, a decided advantage over all other nitrogen plant-foods.

The following list of materials used as a source of nitrogen, in making commercial fertilizers, shows the percentage of nitrogen in each:

	Per Cent Nitrogen.
Nitrate of Soda	15 to 16
Sulphate of ammonia	19 to 22
Dried blood	10 to 14
Tankage	5 to 12
Dried fish scrap	9 to 11
Cotton-seed meal	6 to 7
Castor pomace	5 to 6
Tobacco stems	2 to 3
Bone meal	2 to 4
Peruvian guano	6 to 10
Nitrate of potash	13 to 14
Manures	0.3 to 1.6

The following table shows the number of pounds of nitrogen removed in one year from one acre by the crop specified:

	Crop.		Nitrogen.
Wheat	35	bushels.	59 lbs.
Rye	30	bushels.	51 lbs.
Barley	40	bushels.	46 lbs.
Oats	60	bushels.	55 lbs.
Corn	50	bushels.	67 lbs.
Buckwheat	30	bushels.	35 lbs.
Potatoes	200	bushels.	46 lbs.
Sugar beets	15½	tons.	69 lbs.
Mangel-wurzel	22	tons.	150 lbs.
Meadow hay	2½	tons, dry.	83 lbs.
Timothy	2	tons, dry.	89 lbs.
Green corn	11½	tons.	85 lbs.
Red clover	2	tons, dry.	105 lbs.
Lucerne	8	tons.	113 lbs.
Sugar cane	20	tons.	153 lbs.
Sorghum	15	tons.	121 lbs.
Cotton	750	lbs., seed.	26 lbs.
Hops	600	lbs., seed.	84 lbs.
Tobacco	1600	lbs.	89 lbs.
Grapes	2	tons.	32 lbs.
Cabbage	31	tons.	150 lbs.
Cucumbers	25	tons.	86 lbs.
Onions	11½	tons.	72 lbs.
Oranges	10	tons.	24 lbs.

The following table shows the quantity of fertilizer desirable for one acre, with the percentage of nitrogen in it. The quantities given are for the average soil, under average conditions, the character and amounts of other plant-foods in the fertilizer not being considered here:

	Fertilizer.	Nitrogen in Fertilizer.
	Per Acre.	*Per Cent.*
Artichokes	600 lbs.	3
Asparagus	500	4.5
Barley	500	1
Beans	700	2
Beets, garden	400	3
Beets, sugar	1,000	6
Benne	550	5
Blackberry	650	3
Buckwheat	300	3
Cabbage	1,500	4
Cane, sugar	750	3

	Fertilizer.	Nitrogen in Fertilizer.
	Per Acre.	*Per Cent.*
Carrots	500	3
Cassava	300	3
Celery	700	4
Corn	550	2.5
Cotton	900	2
Cranberry	600	2
Cucumbers	1,200	3
Currants	550	3
Egg plant	2,000	4
Flax	400	3
Hemp	800	5.5
Hops	1,000	3
Horseradish	600	4
Lettuce	1,000	5
Melons	1,200	3
Mint	700	4
Mustard	300	3
Oats	400	2.5
Onions	1,500	4
	Per Tree.	
Oranges	20	3
	Per Acre.	
Peas	900	1.5
Pineapples	2,000	3
Potatoes, Irish	700	3
Potatoes, sweet	550	4
Radishes	800	3
Ramie	650	2
Rape	600	4
Raspberry	700	3
Rhubarb	1,300	3
Rice	450	3
Spinach	1,200	3
Squash	1,600	4
Strawberry	1,500	3
Sunflower	500	3
Tobacco	600	3.5
Tomatoes	1,200	4
Trees, general	600	3
Turnips	450	2.5
Wheat	400	3

Artificial fertilizers are used freely by the fruit-growers of California, and their use among the farmers is steadily increasing. One reason why they are not used more extensively is due to the fact that they have to be imported into the State. It is also a fact that the total amount used is only a small percentage of the amount that should be used. Every one will admit that the use of fertilizers in this State is small compared with their use in Germany, for in that country they are used more extensively than in any other nation; yet Dr. Maercker, the Director of the Government Agricultural Experiment Station at Halle, Germany, says: "Just think! the consumption of potash (in the fertilizers) alone in Germany must increase 700 per cent before the normal demands of the lands and farms are met and satisfied." (Arbeiter der Deutsches Landwirthschafts Gesellschaft Zusammengestellt von G. Siemssen, Berlin, 1896.)

236 NITRATE OF SODA AND ORANGES.

To illustrate the value of nitrate of soda to one crop alone, in this State, the orange may be taken as an example. Many orange groves in California are to-day yielding small crops, because the trees have not been properly cultivated and fertilized. The trees remove plant-food from the soil just the same as wheat, yet no farmer would think of trying to raise wheat for ten or fifteen consecutive years on the same soil. This sterility, or exhaustion, of the plant-food can not be remedied by cultivation; the foods must be replaced in the form of fertilizers. Ordinary manures, etc., do not give nitrogen enough, as is shown in the table at top of page 184. Artificial fertilizers raise the yield of the trees to a maximum, and at the same time give the trees that vigor of growth which enables them to resist climatic changes and parasitic attacks.

A long list of experiments carried out in many places shows that nitrate of soda is the best source of nitrogenous food for the orange tree. Sulphate of ammonia, for example, has to undergo a change in the soil before its nitrogen is available for plant-food, so that much of it is lost, while the nitrogen of the nitrate of soda is at once assimilated by the growing tree or plant.

Many analyses have been made of the oranges of Florida and California. Taking the average orange into consideration there are, according to Prof. J. J. Earle, 385 ounces of nitrogen in 44,000 oranges. While the chemical composition of the orange tree varies widely, the following gives the average of many analyses; in 100 parts there are the following:

	Nitrogen.	Phosphoric Acid.	Potash.	Lime.
Fruit	0.32	0.38	0.32	0.43
Leaves	0.70	0.10	0.32	0.71
Trunk and branches	0.70	0.43	0.58	0.80

As the foliage is perennial, and the trunk and branches of slow growth and subjected to limited pruning, the greater portion of the plant-food assimilated is expended upon the fruit.

Taking an acre of orange grove, then, as containing about 100 trees, and producing 12 tons of fruit, this crop would contain the following:

	Pounds.
Nitrogen	85
Phosphoric acid	102
Potash	85

The lime not being taken into account, as it abounds in most soils.

On this basis, the formula of a chemical manure that would restore these elements to the soil would be as follows, for one acre:

	Pounds.
Nitrate of soda	560
Superphosphate of lime (16% soluble)	612
Sulphate of potash	170

Of course this formula would require modification for special conditions, as where gypsum (sulphate of lime) would be required in some districts, etc.

To look at the necessity of using fertilizers in another light, the amount of plant-food in the form of nitrogen in the oranges shipped out of the State may be considered. The number of oranges in a box varies, according to size, from as low as 80 to as high as 200. In a carload there are 362 boxes, equal to from 28,000 to 72,000, or an average, say, of 44,000 oranges per car. According to Professor Earle's analysis, 44,000 oranges contain 385 ounces (about 24 pounds) of nitrogen and 138.8 ounces (8.3 pounds) of soda, or 32.3 pounds of these chemicals. As the shipments of oranges amount to some 25,000 carloads in one year, there is shipped out of the State each year over 8,075,000 pounds of plant-food—over 4000 tons of nitrate of soda in the oranges alone.

The same form of statistics might be applied to agriculture in general, to all the crops given in the table on pages 184–185, and the results would give some idea of the immense quantities of nitrates taken from the soils of California every year and shipped away.

From this it will be seen that the niter beds may prove, in the near future, a most valuable addition to the resources of the State.

237

ELEVATIONS.

A minus sign (—) before the elevation indicates below sea-level.

	Feet.
Alvarado	20
Amboy, San Bernardino County	608
Ash Hill, San Bernardino County	1,937
Avawatz Mountains, San Bernardino County	6,290
Bagdad, Santa Fé Railroad	781
Barstow, Santa Fé Railroad	2,105
Bennett's Wells, Death Valley, Inyo County	—323
Blackwater Well, San Bernardino County	3,515
Borax Works, Death Valley	—200
Box Spring, San Bernardino County	1,536
Bristol, Santa Fé Railroad	705
Brown's Peak	5,892
Cadiz, Santa Fé Railroad	816
Cameron Salt Lake, Santa Fé Railroad	3,200
Cajon, Santa Fé Railroad	2,927
Cave Springs	3,970
Coleman Borax Field, Death Valley	1,500
Cottonwood Spring, San Bernardino County	2,273
Coyote Wells, San Bernardino County	375
Daggett, Santa Fé Railroad	1,999
Danby, Santa Fé Railroad	1,228
Death Valley, lowest part opposite Bennett's Wells	—427
Edison, Santa Fé Railroad	1,724
Echo Mountain	3,500
Fossil Peak, San Diego County	600
Francis Spring, San Bernardino County	4,220
Furnace Creek, Borax Works, Death Valley	—200
Furnace Springs, Death Valley	—337
Funeral Mountains	6,500
Garlic Springs	2,455
Granite Wells, San Bernardino County	4,200
Granite Spring, San Bernardino County	4,115
Halloran Spring, San Bernardino County	3,272

	Feet.
Harper, Santa Fé Railroad	2,276
Haslet, Santa Fé Railroad	1,860
Hesperia, Santa Fé Railroad	3,184
Hinkley, Santa Fé Railroad	2,156
Indio	—22
Ivanpah	4,238
Java, Santa Fé Railroad	958
Johannesburg	3,500
Kleinfelter, Santa Fé Railroad	1,445
Kramer, Santa Fé Railroad	2,479
Lake Mono, Mono County (6,730)	6,380
Lake Mono Craters	9,137
Lava Mountains, San Bernardino County	5,013
Le Conte Peak	6,580
Leach's Pass	1,959
Leach's Spring	3,535
Los Angeles	270
Ludlow, Santa Fé Railroad	1,775
Mesquite Valley, San Bernardino County	3,764
Mesquite Wells, Death Valley	—228
McBride Peak	13,432
Mojave, Southern Pacific Railroad—Santa Fé Railroad	2,751
Monte Blanco, Coleman borax field, Inyo County	1,500
Mount Dana	12,992
Mount Lyell	13,042
Mount Perry	5,500
Mount Ritter	13,072
Mount San Bernardino	14,000
Mount Smith	6,300
Mount Whitney	14,898
Needles, Santa Fé Railroad, Colorado River	491
Newberry	1,823
Niter Fields, Chili 3,000 to	4,000
No. 2 Lake, San Bernardino County	3,168
Oceanside, Santa Fé Railroad	44
Oro Grande, San Bernardino County	2,625
Owl Peak, San Bernardino County	3,500
Owl Springs, San Bernardino County	1,906
Pilot Peak	5,525
Point of Rocks, Santa Fé Railroad	2,423
Pyramid Peak	6,754

	Feet.
Randsburg, Kern County	3,550
Resting Springs	1,750
Round Mountain, Death Valley	1,790
Salt Wells	307
Salton, Southern Pacific Railroad	—265
San Bernardino	1,075
San Marcos	568
Santa Fé Springs	159
Saratoga Springs, Death Valley	362
Searles Lake, San Bernardino County	1,805
Siberia	1,264
Soda Lake, Sink of Mojave	1,128
Summit	3,819
Table Mountain, San Diego County	850
Telescope Peak, Death Valley	10,937
Victor, Santa Fé Railroad	2,713
Volcano Springs, Southern Pacific Railroad	—265
Willow Creek Ranch	1,397
Waterman, Santa Fé Railroad	2,115
Willard's Lake, San Bernardino County	2,524
Willow Springs, San Bernardino County	2,900
Yucca Springs, San Diego County	240

A PROSPECTOR.

PACK OUTFIT, DEATH VALLEY.

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APPENDIX.

CALIFORNIA STATE MINING BUREAU.

This institution aims to be the chief source of reliable information about the mineral resources and mining industries of California.

It is encouraged in its work by the fact that its publications have been in such demand that large editions are soon exhausted. In fact, copies of them now command high prices in the market.

The publications, as soon as issued, find their way to the scientific, public, and private libraries of all countries.

STATE MINERALOGIST.

The California State Mining Bureau is under the supervision of Hon. Lewis E. Aubury, State Mineralogist by appointment of Hon. Henry T. Gage, Governor of California.

The Mining Bureau is supported by legislative appropriations, and in some degree performs work similar to that of the geological surveys of other States; but its purposes and functions are mainly practical, the scientific work being clearly subordinate to the economic phases of the mineral field, as shown by the organic law governing the Bureau, which is as follows:

SEC. 4. It shall be the duty of said State Mineralogist to make, facilitate, and encourage special studies of the mineral resources and mineral industries of the State. It shall be his duty: To collect statistics concerning the occurrence of the economically important minerals and the methods pursued in making their valuable constituents available for commercial use; to make a collection of typical geological and mineralogical specimens, especially those of economic or commercial importance, such collection constituting the Museum of the State Mining

FERRY BUILDING, SAN FRANCISCO, ONE HALF THE UPPER FLOOR OF WHICH IS OCCUPIED BY THE STATE MINING BUREAU.

Bureau; to provide a library of books, reports, drawings, bearing upon the mineral industries, the sciences of mineralogy and geology, and the arts of mining and metallurgy, such library constituting the Library of the State Mining Bureau; to make a collection of models, drawings, and descriptions of the mechanical appliances used in mining and metallurgical processes; to preserve and so maintain such collections and library as to make them available for reference and examination, and open to public inspection at reasonable hours; to maintain, in effect, a bureau of information concerning the mineral industries of this State, to consist of such collections and library, and to arrange, classify, catalogue, and index the data therein contained, in a manner to make the information available to those desiring it, and to provide a custodian specially qualified to promote this purpose; to make a biennial report to the Board of Trustees of the Mining Bureau, setting forth the important results of his work, and to issue from time to time such bulletins as he may deem advisable concerning the statistics and technology of the mineral industries of this State.

THE BULLETINS.

The field covered by the books issued under this title is shown in the list of publications. Each bulletin deals with only one phase of mining. Many of them are elaborately illustrated with engravings and maps. A nominal price only is asked, in order that those who need them most may obtain a copy.

THE REGISTERS OF MINES.

The Registers of Mines form practically both a State and a County directory of the mines of California, each county being represented in a separate pamphlet. Those who wish to learn the essential facts about any particular mine are referred to them. The facts and figures are given in tabular form, and are accompanied by a topographical map of the county on a large scale, showing location, towns, railroads, roads, etc.

HOME OF THE BUREAU.

The Mining Bureau occupies the north half of the third floor of the Ferry Building, in San Francisco. All visitors and residents are invited to inspect the Museum, Library, and other rooms of the Bureau and gain a personal knowledge of its operations.

THE MUSEUM.

The Museum now contains nearly 16,000 specimens, carefully labeled and attractively arranged in showcases in a great,

MINERAL MUSEUM, CALIFORNIA STATE MINING BUREAU.

LIBRARY AND FREE READING-ROOM, CALIFORNIA STATE MINING BUREAU.

well-lighted hall, where they can be easily studied. The collection of ores from California mines is of course very extensive, and is supplemented by many cases of characteristic ores from the principal mining districts of the world. The educational value of the exhibit is constantly increased by substituting the best specimens obtainable for those of less value.

These mineral collections are not only interesting, beautiful, and in every way attractive to the sightseers of all classes, but are also educational. They show to manufacturers, miners, capitalists, and others the character and quality of the economic minerals of the State, and where they are found. Plans have been formulated to extend the usefulness of the exhibit by special collections, such as one showing the chemical composition of minerals; another showing the mineralogical composition of the sedimentary, metamorphic, and igneous rocks of the State; the petroleum-bearing formations, ore bodies, and their country rocks, etc.

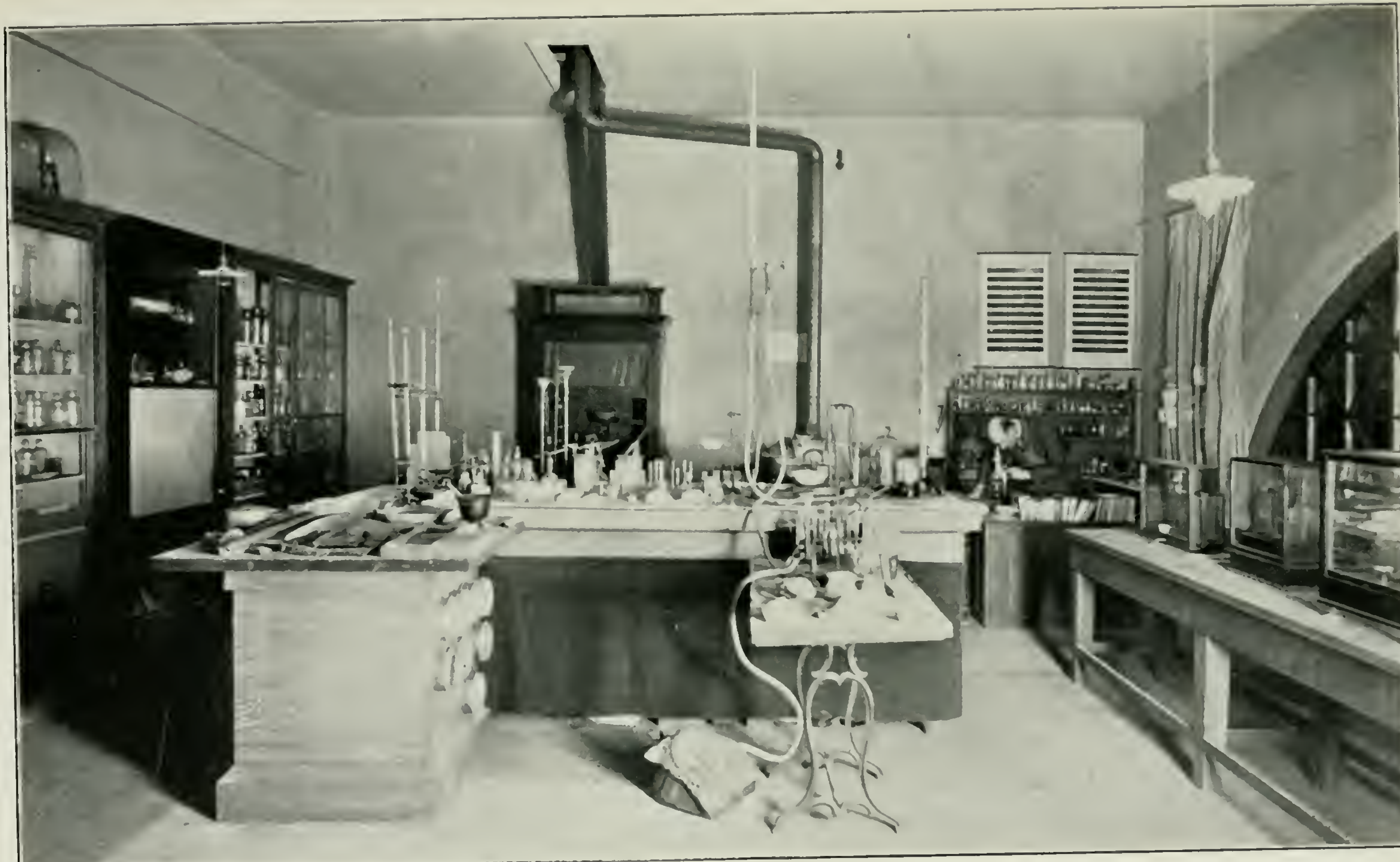
Besides the mineral specimens, there are many models, maps, photographs, and diagrams illustrating the modern practice of mining, milling, and concentrating, and the technology of the mineral industries. An educational series of specimens for high schools is being inaugurated, and new plans are being formulated that will make the Museum even more useful in the future than in the past. Its popularity is shown by the fact that over 58,000 visitors registered last year, while many failed to leave any record of their visit.

THE LIBRARY.

This is the mining reference library of the State, constantly consulted by mining men, and contains between 4000 and 5000 volumes of selected works, in addition to the numerous publications of the Bureau itself. On its shelves will be found reports on geology, mineralogy, mining, etc., published by States, governments, and individuals; the reports of scientific societies at home and abroad; encyclopædias, scientific papers, and magazines; mining publications; and the current literature of mining ever needed in a reference library.

Manufacturers' catalogues of mining and milling machinery by California firms are kept on file. The Registers of Mines form an up-to-date directory for investor and manufacturer.

The librarian's desk is the general bureau of information,



LABORATORY, CALIFORNIA STATE MINING BUREAU.

where visitors from all parts of the world are ever seeking information about all parts of California.

READING-ROOM.

This is a part of the Library Department and is supplied with over one hundred current publications. Visitors will find here various California papers and leading mining journals from all over the world.

The Library and Reading-Room are open to the public from 9 A. M. to 5 P. M. daily, except Sundays and holidays.

THE LABORATORY.

This department identifies for the prospector the minerals he finds, and tells him the nature of the wall rocks or dikes he may encounter in his workings; but this department *does not* do assaying or compete with private assayers. The presence of minerals is determined, but not the percentage present. No charges for this service are made to any resident of the State. Many of the inquiries made of this department have brought capital to the development of new districts. Many technical questions have been asked and answered as to the best chemical and mechanical processes of handling ores and raw material. The laboratory is well equipped.

THE DRAUGHTIN-GROOM.

In this room are prepared scores of maps, from the small ones filling only a part of a page, to the largest County and State maps; and the numerous illustrations, other than photographs, that are constantly being required for the Bulletins and Registers of Mines. In this room, also, will be found a very complete collection of maps of all kinds relating to the industries of the State, and one of the important duties of the department is to make such additions and corrections as will keep the maps up to date. The seeker after information inquires here if he wishes to know about the geology or topography of any district; about the locations of the new camps, or positions of old or abandoned ones; about railroads, stage roads, and trails; or about the working drawings of anything connected with mining.

MINERAL STATISTICS.

One of the features of this institution is its mineral statistics. Their annual compilation by the State Mining Bureau began

DRAUGHTING DEPARTMENT, CALIFORNIA STATE MINING BUREAU.

in 1893. No other State in the Union attempts so elaborate a record, expends so much labor and money on its compilation, or secures so accurate a one.

The State Mining Bureau keeps a careful, up-to-date, and reliable but confidential register of every producing mine, mine-owner, and mineral industry in the State. From them are secured, under pledge of secrecy, reports of output, etc., and all other available sources of information are used in checking, verifying, and supplementing the information so gained. This information is published in an annual tabulated, statistical, single-sheet bulletin, showing the mineral productions by both substances and counties.

LIST OF PUBLICATIONS OF THE CALIFORNIA STATE MINING BUREAU.

FERRY BUILDING, SAN FRANCISCO, CAL.

Publications of this Bureau will be sent on receipt of the requisite amount and postage, as noted below:

(*All publications not mentioned are exhausted.*)

	Price.	Postage.
Report XI—1892, First Biennial	$1.00	$0.15
Report XIII—1896, Third Biennial	1.00	.20
Bulletin No. 2—"Methods of Mine Timbering"	.30	.04
Bulletin No. 5—"Cyanide Process" (4th edition)	.35	.04
Bulletin No. 6—"Gold Mill Practices in California" (3d edition)	.50	.04
Bulletin No. 9—"Mine Drainage, Pumps, etc."	.35	.07
Bulletin No. 15—"Map of Oil City Oil Fields, Fresno County, Cal."	.05	.02
Bulletin No. 16—"Genesis of Petroleum and Asphaltum in California" (3d edition)	.30	.03
Bulletin No. 18—"Mother Lode Region in California"	.35	.06
Bulletin No. 19—"Oil and Gas Yielding Formations in California"	.75	.09
Bulletin No. 21—"Mineral Production of California, 1900"	.05	.02
Bulletin No. 22—"Mineral Production of California for past 14 years"	.05	.02
Bulletin No. 23—"Copper Resources of California"	.50	.12
Bulletin No. 24—"Saline Deposits of California"	.50	.12
Map of Mother Lode	.05	.02
Reconnaissance of the Colorado Desert Mining District, in San Diego County	.15	.02
Register of Mines, with map, Plumas County	.25	.08
Register of Mines, with map, Calaveras County	.25	.08
Register of Mines, with map, Siskiyou County	.25	.08
Register of Mines, with map, Trinity County	.25	.08
Register of Mines, with map, Lake County	.25	.08
Register of Mines, with map, Nevada County	.25	.08
Register of Mines, with map, Placer County	.25	.08
Register of Mines, with map, Shasta County	.25	.08
Register of Mines, with map, El Dorado County	.25	.08
Register of Mines, with map, Inyo County	.25	.08

IN PREPARATION.

Register of Mines, with map, Mariposa County.
Register of Mines, with map, Santa Barbara County.
Register of Mines, with map, San Diego County.
Register of Mines, with map, Kern County.
Register of Mines, with map, San Bernardino County.
Register of Mines, with map, Sierra County.
Bulletin—Quicksilver Mining in California.
Bulletin—Gold Dredging in California.
Bulletin—Gems and Precious Stones of California.

STATISTICS.

MINERAL PRODUCT OF CALIFORNIA FOR 1900.

Mineral Product.	Quantity.	Value.
Antimony	70 tons.	$5,700
Asbestos	50 "	1,250
Asphalt	12,575 "	253,950
Bituminous Rock	25,306 "	71,495
Borax—Refined	1,602 "	165,036
Crude	24,235 "	848,215
Cement	52,000 bbls.	121,000
Chrome	140 tons.	1,400
Clay—Brick	137,191 M.	905,210
Pottery	59,636 tons.	60,956
Coal	176,956 "	535,531
Copper	29,515,512 lbs.	4,748,242
Fuller's Earth	500 tons.	3,750
Gold		15,863,355
Granite	311,803 cu. ft.	295,772
Gypsum	2,522 tons.	10,088
Lead	1,040,000 lbs.	41,600
Lime	312,517 bbls.	283,699
Limestone	32,791 tons.	31,532
Lithia Mica	440 "	11,000
Macadam	360,597 "	262,570
Magnesite	2,252 "	19,333
Manganese	131 "	1,310
Marble	4,103 cu. ft.	5,891
Mineral Paint	529 tons.	3,993
Mineral Water	2,456,115 gals.	268,607
Natural Gas	40,565,500 cu. ft.	34,578
Paving Blocks	1,192 M.	23,775
Petroleum	4,329,950 bbls.	4,152,928
Pyrites	3,642 tons.	21,133
Quartz Crystals		18,000
Quicksilver	26,317 flasks.	1,182,786
Rubble	428,690 tons.	299,072
Salt	89,338 "	204,754
Sand—Glass	2,000 "	2,000
Quartz	200 "	200
Sandstone	378,468 cu. ft.	254,140
Serpentine	350 " "	2,000
Silver		1,510,344
Soda	1,000 tons.	50,000
Slate	3,500 squares.	26,250
Tourmaline		500
Turquoise	500 lbs.	20,000
Total		$32,622,945

RANK OF THE COUNTIES AS MINERAL PRODUCERS FOR THE YEAR 1900.

1.	Shasta	$5,574,026
2.	Los Angeles	2,155,198
3.	San Bernardino	1,965,143
4.	Nevada	1,916,899
5.	Calaveras	1,905,856
6.	Kern	1,867,856
7.	Tuolumne	1,659,258
8.	Amador	1,479,009
9.	Placer	1,128,882
10.	Siskiyou	1,010,383
11.	Mono	752,121
12.	Trinity	698,689
13.	Sierra	663,159
14.	Alameda	639,771
15.	Fresno	609,847
16.	Santa Barbara	528,438
17.	Butte	500,786
18.	Santa Clara	497,386
19.	Napa	493,100
20.	Ventura	476,161
21.	Inyo	420,586
22.	El Dorado	426,420
23.	San Diego	402,061
24.	Plumas	369,379
25.	Riverside	285,112
26.	Yuba	284,631
27.	Madera	268,467
28.	Sacramento	259,439
29.	Orange	$259,174
30.	San Benito	205,650
31.	Marin	202,500
32.	Santa Cruz	191,091
33.	Lake	172,745
34.	Mariposa	171,516
35.	Sonoma	157,135
36.	Contra Costa	146,900
37.	Humboldt	118,827
38.	San Luis Obispo	85,626
39.	San Francisco	58,400
40.	San Joaquin	39,862
41.	Solano	24,700
42.	Tulare	21,566
43.	Stanislaus	21,405
44.	Lassen	20,483
45.	Monterey	19,175
46.	San Mateo	16,500
47.	Colusa	13,930
48.	Mendocino	8,448
49.	Kings	5,000
50.	Del Norte	3,483
51.	Tehama	2,200
52.	Yolo	1,760
	Unapportioned	1,406,803
	Total	$32,622,945

CALIFORNIA'S GOLD RECORD.

1848	$245,301	1876	$15,610,723
1849	10,151,360	1877	16,501,268
1850	41,273,106	1878	18,839,141
1851	75,938,232	1879	19,626,654
1852	81,294,700	1880	20,030,761
1853	67,613,487	1881	19,223,155
1854	69,433,931	1882	17,146,416
1855	55,485,395	1883	24,316,873
1856	57,509,411	1884	13,600,000
1857	43,628,172	1885	12,661,044
1858	46,591,140	1886	14,716,506
1859	45,846,599	1887	13,588,614
1860	44,095,163	1888	12,750,000
1861	41,884,995	1889	11,212,913
1862	38,854,668	1890	12,309,793
1863	23,501,736	1891	12,728,869
1864	24,071,423	1892	12,571,900
1865	17,930,858	1893	12,422,811
1866	17,123,867	1894	13,923,281
1867	18,265,452	1895	15,334,317
1868	17,555,867	1896	17,181,562
1869	18,229,044	1897	15,871,401
1870	17,458,133	1898	15,906,478
1871	17,477,885	1899	15,336,031
1872	15,482,194	1900	15,863,355
1873	15,019,210		
1874	17,264,836	Total	$1,345,376,044
1875	16,876,009		

INDEX.

Numbers Refer to Subheads.

P A C I F
MODOC
ALTURAS
LASSEN
SUSANVILLE
PLUMAS
QUINCY
SIERRA
DOWNIEVILLE
NEVADA
NEVADA CITY
PLACER
AUBURN
EL DORADO
PLACERVILLE
ALPINE
MARKLEEVILLE
BRIDGEPORT
AMADOR
JACKSON
CALAVERAS
TUOLUMNE
SONORA
MARIPOSA
MERCED
STANISLAUS
SACRAMENTO
YOLO
WOODLAND
SUTTER
YUBA CITY
MARYSVILLE
BUTTE
OROVILLE
Chico
GLENN
WILLOWS
COLUSA
TEHAMA
RED BLUFF
SHASTA
REDDING
SISKIYOU
YREKA
TRINITY
WEAVERVILLE
HUMBOLDT
EUREKA
DEL NORTE
CRESCENT CITY
MENDOCINO
UKIAH
LAKE
LAKEPORT
NAPA
SONOMA
SANTA ROSA
MARIN
SAN RAFAEL
SOLANO
FAIRFIELD
CONTRA COSTA
MARTINEZ
ALAMEDA
OAKLAND
SAN FRANCISCO
SAN MATEO
REDWOOD CITY
SANTA CLARA
SAN JOSE
STOCKTON
Lake Tahoe
Sacramento River

F I C
O C E A N
MONTEREY
SAN LUIS OBISPO
SANTA BARBARA
SAN BENITO
SANTA CRUZ
FRESNO
MADERA
HANFORD
VISALIA
TULARE LAKE
SALINAS
HOLLISTER
SANTA CRUZ
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
Oxnard
Paso Robles
Cambria
Bradley
Lompoc
Santa Cruz Is.
Santa Rosa Is.

MAP OF

CALIFORNIA

Showing the Approximate Location
of the Principal

SALINE DEPOSITS

OF THE STATE,

To accompany Bulletin No. 24, "The Saline Deposits of California,"

ISSUED BY THE

CALIFORNIA STATE MINING BUREAU

Ferry Building, SAN FRANCISCO,

UNDER THE DIRECTION OF

LEWIS E. AUBURY, STATE MINERALOGIST,

BY AUTHORITY OF

HENRY T. GAGE, GOVERNOR OF THE STATE OF CALIFORNIA.

1902

SCALE OF MILES.

LEGEND

○ *BORAX*
● *SALT*
⊕ *SODA*
⊘ *NITRE*

N
S


INYO
TULARE
KERN
SAN BERNARDINO
DESERT
MOJAVE
LOS ANGELES
VENTURA
ORANGE
RIVERSIDE
SAN DIEGO
COLORADO DESERT
VALLEY
INDEPENDENCE
Independence Sta.
Lone Pine
Cerro Gordo
Keeler
Olancha
Darwin
Panamint
Ballarat
Summit
Kelleys
Borax Works
Borax Flat
Randsburg
Johannesburg
Pilot Butte Spg.
Freeman
Kernville
Weldon
Havilah
Woody
Porterville
Visalia
Exeter
Tulare
Mineral King
Kaweah
BAKERSFIELD
Famoso
Tehachapi
The Loop
Mojave
Rosamond
Lancaster
Acton
Newhall
Yucca
Kramer
Harper
Barstow
Daggett
Old Camp Cady
Mojave Riv.
Ivanpah
Vanderbilt
Manvel
Blake
Needles
Siberia
Danby
Dale
Rosemine
Pine Lake
Oro Grande
Unadilla
Quail
Fairmont
Ozenaa
Nordhoff
VENTURA
Santa Paula
Montalvo
Oxnard
Conejo
Liberty
LOS ANGELES
Burbank
Pasadena
Monrovia
San Dimas
Ontario
Port Los Angeles
Santa Monica
Soldiers Home
Redondo
San Pedro
Long Beach
SANTA ANA
Tustin
Whittier
SAN BERNARDINO
Highland
Redlands
RIVERSIDE
Banning
Palm Springs
Indio
Lakeview
San Jacinto
Perris
Temescal
Elsinore
Willard
El Toro
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Linda Rosa
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Mammoth Tank
Pala
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Oceanside
Escondido
Encinitas
Ramona
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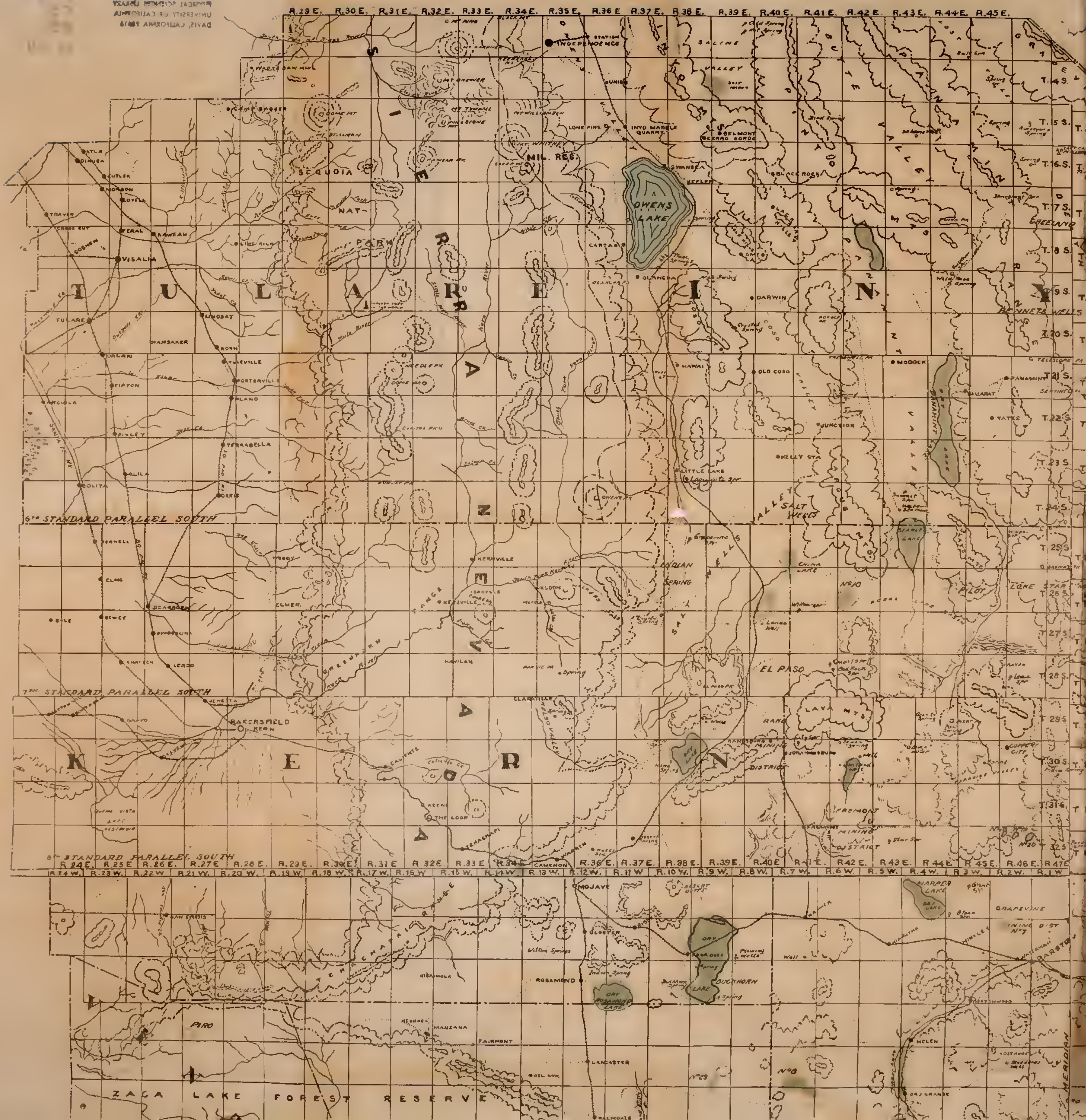
Banner
Borego Sprs.
Foster
Lake Side
Linda Vista
Descanso
La Jolla
Pacific Beach
El Cajon
SAN DIEGO
Coronado
La Presa
National City
Tia Juana
Campo
Indian Wells
Imperial
Pilot Knob
Yuma
Ogilby
Hedges
Picacho
Blythe
Ehrenberg
Parker
Colorado River
Santa Catalina Is.
San Clemente Is.
Santa Barbara Is.



R.29 E. R.30 E. R.31 E. R.32 E. R.33 E. R.34 E. R.35 E. R.36 E. R.37 E. R.38 E. R.39 E. R.40 E. R.41 E. R.42 E. R.43 E. R.44 E. R.45 E.
INDEPENDENCE
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MT. WHITNEY
MIL. RES.
LONE PINE
INYO MARBLE QUARRY
BELMONT
CERRO GORDO
SWANSEA
KEELER
OWENS LAKE
CARTAGO
OLANCHA
DARWIN
SEQUOIA NAT- PARK
VISALIA
TULARE
LINDSAY
HANSAKER
PORTERVILLE
TIPTON
PLANO
TERRABELLA
ALILA
DELANO
6TH STANDARD PARALLEL SOUTH
7TH STANDARD PARALLEL SOUTH
8TH STANDARD PARALLEL SOUTH
T U L A R E
I N Y O
S I E R R A
N E V A D A
K E R N
HAWAI
OLD COSO
MODOCK
PANAMINT
JUNCTION
KELLY STA
TATES
LITTLE LAKE
SALT WELLS
VALLEY
INDIAN SPRING
KERNVILLE
KEYSVILLE
ELMER
HAVILAH
EL PASO
LAVA MTS
RANDSBURG MINING DISTRICT
FREMONT MINING DISTRICT
BAKERSFIELD
KERN
CALIENTE
KEENE
THE LOOP
TEHACHAPI
BUENA VISTA LAKE
BENNETS WELLS
LONE STAR
MOJAVE
ROSAMOND
DRY ROSAMOND LAKE
DRY LAKE
BUCKHORN
HARPER LAKE
GRAPEVINE
BARSTOW
DAGGETT
LANCASTER
FAIRMONT
MANZANA
PALMDALE
PIRU
ZACA LAKE FOREST RESERVE
T.14 S. T.15 S. T.16 S. T.17 S. T.18 S. T.19 S. T.20 S. T.21 S. T.22 S. T.23 S. T.24 S. T.25 S. T.26 S. T.27 S. T.28 S. T.29 S. T.30 S. T.31 S. T.32 S.
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MERIDIAN

MAP OF THE

Saline Deposits of the Southern Portion of California

To accompany Bulletin No. 24,

ISSUED BY THE

CALIFORNIA STATE MINING BUREAU,

FERRY BUILDING, SAN FRANCISCO.

By G. E. BAILEY, E.M., Ph.D.

LEWIS E. AUBURY, - - - STATE MINERALOGIST.

BY AUTHORITY OF

HENRY T. GAGE, GOVERNOR OF CALIFORNIA.

1902


ZACA LAKE FOREST RESERVE
LOS ANGELES
ORO GRANDE MINING DISTRICT
SAN GABRIEL FOREST RESERVE
SAN BERNARDINO
SAN BERNARDINO BASE LINE
SANTA MONICA MTS
LOS ANGELES
PASADENA
SAN FERNANDO VALLEY
VENTURA
SANTA PAULA
OXNARD
SAN BERNARDINO
RIVERSIDE
COLTON
CHINO
WHITTIER
SANTA MONICA BAY
REDONDO
SANTA ANA
ORANGE
TUSTIN
NEWPORT
IRVINE
EL TORO
LAGUNA
CAPISTRANO
SAN JUAN
TEMECULA
FALLBROOK
OCEANSIDE
CARLSBAD
ENCINITOS
DEL MAR
LA JOLLA
PACIFIC BEACH
OCEAN BEACH
SAN DIEGO
PT. LOMA
SAN PEDRO CHANNEL
GULF OF SANTA CATALINA
SANTA CATALINA ISLAND
SAN CLEMENTE ISD.
SAN NICOLAS ID.
SANTA BARBARA ISLAND
SAN PEDRO BAY
NEWPORT BAY
PT. VINCENT
MENIFEE MINING DISTRICT
PINACATE MINING DISTRICT


S A N B E R N A R D I N O
R I V E R S I D E
S A N D I E G O
BRISTOL LAKE
DRY LAKE
CADIZ LAKE
DANBY LAKE
SAN BERNARDINO BASE LINE
R.1 E. R.2 E. R.3 E. R.4 E. R.5 E. R.6 E. R.7 E. R.8 E. R.9 E. R.10 E. R.11 E. R.12 E. R.13 E. R.14 E. R.15 E. R.16 E. R.17 E. R.18 E. R.19 E. R.20 E. R.21 E. R.22 E. R.23 E. R.24 E. R.25 E.
T.7 N. T.6 N. T.5 N. T.4 N. T.3 N. T.2 N. T.1 N.
T.1 S. T.2 S. T.3 S. T.4 S. T.5 S. T.6 S. T.7 S. T.8 S. T.9 S. T.10 S. T.11 S. T.12 S. T.13 S. T.14 S. T.15 S. T.16 S. T.17 S. T.18 S.
1ST STANDARD PARALLEL SOUTH
2ND STANDARD PARALLEL SOUTH
3RD STANDARD PARALLEL SOUTH
PALMS MINING DISTRICT
MORONGO MINING DIST
VIRGINIA DALE MINING DISTRICT
COTTONWOOD MINING DISTRICT
PINTO MTS
PALM SPRINGS
SAN JACINTO FOREST RES.
SAN JACINTO UNSURVEYED RANGE
WALTERS
SALTON
DRY BED OF SALTON LAKE
VOLCANO
FLOWING WELLS
MAMMOTH TANK
CACTUS LAKE
YUMA INDIAN RES
YUMA
COLORADO RIVER